THE GLASS INDUSTRY

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ENEMY OWNED PATENTS MADE AVAILABLE TO U. S. GLASS INDUSTRY

Editor's Note: Under wartime powers the Alien Property Custodian has seized or vested thousands of foreign owned U. S. patents and is making them available to American industry. These are the patents formerly controlled by enemy nationals. This government agency has pledged to foster the active use of the store of technical knowledge which these patents represent. Responsible individuals and manufacturers having a bona fide interest in the use of these patents may secure from the A.P.C. a free but non-exclusive license extending for the life of the patents. A license application fee of $50 will be charged for each single patent, plus $5 for each additional related patent covered in the same license.

In instances where the value of the disclosures in vested patents would be increased by further research the A.P.C. even plans to cooperate with manufacturers to see that adequate research is undertaken in industrial laboratories and in the research laboratories of universities, endowed foundations, and the government.

In the glass industry the fruits of foreign invention had in many cases previously been made available to America through broad licensing agreements which were apparently common between individual manufacturers. Still the initial vesting order of the A.P.C. led to the seizure of approximately a hundred glass patents, and an even larger number has since been seized.

For most persons patents make dull reading, and the study of all of the vested glass patents is a formidable task to even contemplate. In this situation The Glass Industry has assumed the responsibility of studying these patents and briefly summarizing them for its readers. The following summary encompasses most of the patents in the initial seizure. The guiding principle has been to present enough detail to allow the reader to decide whether an individual patent warrants his further study, with a view to securing an operating license.

Correspondence concerning licenses under vested patents should be addressed to the Alien Property Custodian, Chicago, Illinois.

Compositions:

Glass compositions are the subject of four vested patents formerly controlled by the Jenaer Glaswerk Schott & Gen., Jena, Germany. In each instance the inventor was Edwin Berger. Patent 1,943,051 is an optical glass with more than 25 per cent alkaline earth oxides, substantial amounts of lead and antimony oxides, titania up to 20 per cent and silica not exceeding 20 per cent. The purpose of the titania is to reduce the attack of optical elements to perspiration and other weak acids which may cause staining. Heat absorbing glasses high in P_2O_5 and boric oxide and with only minor percentages of silica are disclosed in patent 1,961,603. Iron oxide in the reduced form FeO contributes to this effect, and is said to have greater absorption at the red end of the spectrum when associated with P_2O_5 rather than with silica. Glasses for the same purpose but containing about 27 per cent silica in conjunction with slightly over 50 per cent P_2O_5 are the subject matter in patent 2,194,784. Practically silica-free glasses for resistance to discoloration by sodium vapor in lamps, are described in 2,090,098. For example 10 to 40 per cent boric oxide, and 10 to 35 per cent alumina are combined with such bivalent oxides as baryta, the latter amounting to at least 40 per cent of the composition.

Patents 1,964,629 and 2,100,391 granted to Hans G. Grimm and Paul Huppert (I. G. Farbenindustrie Aktiengesellschaft, Frankfort-on-the-Main, Germany) concern the use of Al_2O_3 and P_2O_5 as major vitrifying agents in whole or partial replacement of silica. In the earlier patent these oxides are used in equimolecular proportions, while in the latter the alumina exceeds the P_2O_5.

The process of manufacturing barium glass "which consists in melting barium silicate with glass-forming ingredients" is covered by patent 1,694,831 granted to Fritz Rothe and Hans Brenek of Rhenania-Kunheim, Verein Chemischer Fabriken, Aktiengesellschaft, Berlin.

Glasses protective against ultra-violet rays, and containing 5 to 50 per cent neodymium oxide plus some vanadium oxide are disclosed in 2,219,122 isued to Franz Weidert and Hans Loffler of Degea Aktiengesellschaft, Berlin.

In 1,684,332 granted to Max Thomas (Patent-Treuhand-Gesellschaft für Elektrische Gluhlampen m.b.H., Berlin) such claims appear as are necessary to represent his discovery that such compositions as the following make excellent electrical resistors: 10 per cent Fe_2O_3 (which is essential), 67 per cent SiO_2, 3 per cent K_2O, 10 per cent CaO and 10 per cent BaO. The same company controlled Marello Pirani's patent 1,713,394 for the manufacture of translucent hollow glass articles such as milk-glass bulbs for incandescent lamps. Glass was finely pulverized and sintered (without refining) to such a degree as would allow a gob to be formed; a charge of the sintered glass was then picked up by means of a glass tube through which it was blown to shape with the sintered glass still retaining air bubbles.

Glasses for electrical discharge lamps are described in 2,087,762 issued to Hermann Krefft of Berlin-Friedrichshagen and 2,099,602 to Hellmuth Fischer of Ilmenau, Germany. Krefft found that the blackening of the glass envelope of a mercury vapor arc lamp was prevented by mixing 0.2-5 per cent caesium to the vaporiz-

ing mercury base if a suitable aluminum silicate glass was also used. The glass contains about 60 per cent silica, more than 20 per cent alumina, together with boric oxide, lime and magnesium oxides, but with soda and potash omitted. In Fischer's glass which has high luminescence in mercury vapor, repression of the iron to less than 0.05 per cent is essential. Included in the glass are luminescence-affording compounds from the group consisting of uranium, tin, copper, antimony, niobium, tantalum, lanthanum and tungsten, their individual amounts varying but not exceeding 0.05 per cent in any case. Fischer also held patent 2,183,961 on a method of combining two or more types of glass to produce a stratified glass tube.

Compositions for which the results depend largely on method of preparation are dealt with in patents 1,868,-065 to George Jaeckel (Sendlinger Optische Glaswerke G.m.b.H. of Berlin-Zehlendorf), 1,948,461 to Ignatz Kreidl of Vienna, and 2,007,349 to Ludwig Schertel (Th. Goldschmidt A.-G., of Essen-Ruhr, Germany). To avoid the discoloring of glass by the iron oxide in refractory pots, Jaeckel includes neutralizing or decoloring agents such as nickel oxide in the clay from which the pots are made. Kreidl makes opaque glasses and enamels by including gas forming compounds such as nitrates, together with an adsorptive clay which holds onto the bubbles of gas to keep them within the glass. Schertel's idea was that of making lead optical glass by first melting only the lead oxide and silica on a hearth to form a fused lead silicate which was then crushed and melted with other constituents.

Another German patent is 2,270,718 issued to Franz Skaupy and Gustav Weissenberg for the manufacture of fused silica ware by any one of a number of sintering processes whereby complete fusion is avoided.

Feeding, Forming and Shaping:

Fig. 1 shows the method of patent 1,121,143 proposed by Bernhard Engels of Waldenburg-Altwasser for feeding glass alternately in two directions. Glass from the forehearth falls onto a tiltable guide which feeds first to one side and then to the other without interruption of the flow of glass. Heat is applied to the free half of the table from burners K. In patent 1,589,337 Heinrich Severn of Sasbach, Germany, describes a means of removing the chilled glass from the forehearth into a clarifying chamber, after molds have dipped into the glass.

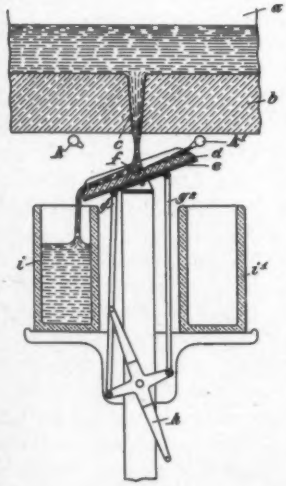


Fig. 1. 2,121,143: Engels. Glass fed to a tiltable guide is led first to one side and then the other.

In the bottle blowing machine of 1,676,981 Guglielmo de Renzis of Sarzana, Italy, utilizes a mold in which the glass is stationary on a fixed base while the two-section mold is given an oscillating rotation of one-third to one-half turn in both directions.

The formation of hand-made container blanks on a gang mold is the subject of 1,948,682 granted to Adolf Schiller of Berlin-Schoneberg. Max Aftergut from the same place of residence was the inventor of patent 1,875,202 which relates to an automatic glass blowing machine. Particular details are the air cylinders which control and measure the blowing air for both the parison and finishing molds.

Patent 1,844,185 to Karl Schneegluth of Amberg, Germany (Amberger Flashchenhutten A.G.) describes means of indenting the necks of containers while they are still in the mold, so that the toggle-lever type of closure may be applied.

Electric Discharge Apparatus:

In this group are patents 1,755,983 and 1,815,146 issued to Bernard Erber of Vienna, with F. Ganther collaborating on the former which is concerned with means of fusing in lead-in wires. The second patent covers a means of forming a glass article pierced by holes formed by a metallic core. The core is coated with metallic oxide and with a layer containing graphite and talc so that the wire can be easily withdrawn when the glass cools. Evald Theiler of Berlin-Wilmersdorf,, Germany also described in patent 2,055,884 a means of producing similarly pierced ware.

In 2,178,226 Kurt Diels of Berlin (Telefunken Gesellschaft für Drahtlose Telegraphie m.b.H., Berlin) tells of shaping a flat bottomed cathode ray tube by blowing it against a flat plate while the remainder of the tube is unconfined. A similar molding process is described in 2,274,691 issued to Max Heim of Fernseh G.m.b.H., Berlin-Zehlendorf. Apparatus for fusing angularly placed tubes onto the necks of lamps is covered by 1,584,661 issued to Erich Schott and others of Jenaer Glaswerk Schott & Gen., Jena, Germany. Karl Steimel, a co-worker of Kurt Diels' was the inventor in patent 2,205,582 wherein a high frequency field is used for the heating step in connection with processes of sealing metal electrodes into glass.

Otto Baier's patent 2,217,398 (to C. Lorenz Aktiengesellschaft, Berlin) tells how glass to metal seals can be made by applying molten glass to the space between tubes of metal and glass, and then by telescoping one within the other to force the molten glass into the space between them. A similar tube to tube seal is obtained by Alfred Wendler of Berlin-Dahlem by slipping a metal tube into one of glass, then heating one section of the glass tube to soften it, and finally drawing the metal through the heated zone while the glass is stretched or drawn to cause it to seal as a film to the metal tube (2,263,601). Edmund Lopp, a Berlin associate of Otto Baier's was the inventor of the method of 2,268,666 for sealing a glass cylinder to a ceramic tube.

In the process of 1,697,780 (Yukitoshi Saka kura of Shibuyamachi, Toyotamagun, Tokyo-Fu, Japan) for making incandescent lamps, "the filament, its supports and lead in means, properly brought together to form the lamp contents, are slidably held within the blow pipe and after the lamp bulb has been blown the lamp contents are forwarded into the bulb just formed and are immediately sealed thereto."

Patents 1,848,312 to Luigi Bruzzane of Genoa, Italy, and 1,740,443 to Karl Donat (Siemen-Schuckertwerke

Gesellschaft Mit Beschrankter Haftung, of Berlin) deal with means of fusing a glass charge into a metal receptacle, the former with the purpose of making spark plugs.

Ampoules and Tube Reworking:

In the group of seized patents are the following which were issued to Jakob Dichter of Berlin: 1,962,985; 1,981,692; 2,087,947 and 2,101,213. The first concerns an automatic rotary machine for forming ampoules from tubes, the second a means of feeding short tube sections to such a machine, and the other two are also concerned with ampoule manufacture.

An ampoule machine is described also in patent 1,864,023 issued to Willy Ledig of Patent-Treuhand-Gesellschaft für Elektrische Gluhlampen m.b.H. of Berlin. A device for opening vials is covered by 1,805,369 granted to Wilhelm Merck of Dormstadt, Germany.

Forming Miscellaneous Ware:

In patent 1,674,182 Fritz Siegheim of Berlin covered a method of making double walled vacuum flasks by inserting a wide mouth bottle into another open ended bottle, sealing their edges together and then reforming the top portion of the assemblage within a mold. Also seized by the A.P.C. was patent 1,623,311 in which Wilhelm Hodecker of Ilmenau, Germany, described means of making double walled vessels by first forming the outer flask with an inwardly extending cup, which was next filled with molten glass from which the inner vessel was finally blown.

Patent 2,123,937 granted to Bernhard Engels of Waldenburg-Altwasser, Germany, tells how large thick walled cylinders can be cast from molten glass by pouring the glass into the annular space between the mold core and its outer wall while the mold is kept rotating; by such means the successive layers of glass merge together.

A method for forming lenses is covered by George Jaeckel's patent 2,272,119 (Sendlinger Optische Glaswerke G.m.b.H., Berlin-Zehlendorf.)

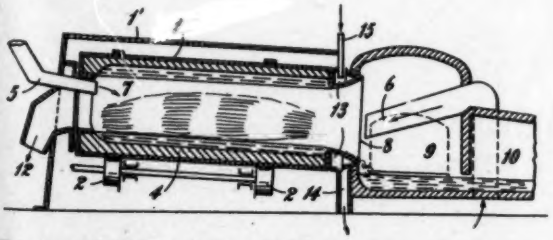


Fig. 2. 1,863,708: Zotos. Melting furnace which rotates on trunions.

Miscellaneous Processes:

The process by which George Zotos of Berlin actually carried to commercial development his idea for melting glass in the rotary furnace of Fig. 2, is covered by patent 1,863,708. This process is described fully on pages 393-396 of the September, 1941 issue of Glass Industry.

Equally novel is Kurt Kunzel's idea for adapting a shaft furnace to the melting of glass compositions in patent 1,676,267. In patent 1,625,435 issued to Gerhard Stein of Neusornewitz, Germany, a pot for glass melting is molded with open grooves on the bottom for facility in melting.

Patent 1,782,169 issued to Kiyoshe Kamita of the Asahi Glass Co. Ltd. of Tokyo covers "a process for preventing the weathering, clouding and tarnishing of the surface of glass which comprises treating the surface of glass with an acid gas at a temperature between 300 and 600° C., the gas being a mixture of a gas normally present in the lehr and additional acid gases."

For fitting glass stoppers to bottle necks, a process of chipping both neck and stopper by means of hard metal cutters is covered by patent 2,010,257 issued to Adolf Fehse of Berlin.

Processes for spinning and winding glass fibers are discussed in patents 1,968,693 to O. H. A. Kroger and O. A. Oswald of Hamburg, and 2,187,094 to Johannes Pink (Patent-Treuhand-Gesellschaft für Elektrishe Gluhlampen m.b.H., Berlin).

Sheet and Plate Glass:

In the first group of patents seized by the A.P.C. were four which had issued to Bernard Engels of Waldenburg-Altwasser, Silesia, Germany, on various aspects of sheet glass manufacture. In 1,892,459 he draws a sheet vertically from a pot and provides for the gradual elevation of the pot as it is emptied so that the distance from the surface of the bath to the first rolls can be kept from changing. In patent 1,910,759 Engels flashes sheet glass by the special drawing nozzle of Fig. 3 which has a longitudinal receptacle which holds the flashing glass as it is drawn. His patent 1,941,392 is also concerned with compounded sheet glass, in this instance drawing a base sheet vertically, and at a place somewhat above its meniscus flowing a thinner sheet onto one or both sides. The essence of patent 2,237,343 for tempering glass sheets consists of applying cooling air to both sides of a sheet while it is held under tension in an approximately horizontal plane.

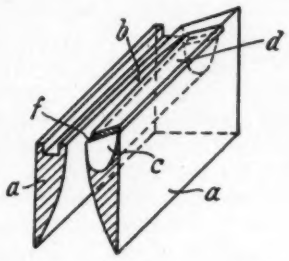


Fig. 3. 1,910,759: Engels. Drawing nozzle for flashed sheet glass which feeds the flashed coating from receptacle C.

Arthur E. Spinasse who in 1936 resided at Mount Vernon, Ohio, was the inventor of 1,882,262 covering means of drawing sheet vertically from a wholly submerged V shaped pot in the forehearth.

Seized patents assigned to Schlessische Spiegelglas-Manufaetur Carl Tielsch, G.m.b.H., Walden-Altwasser, Germany, were 1,859,880 granted to Karl Macht, 2,062,228 to Armand Lamesch and 1,790,043 to Adolph Engels, all for glass reinforced by wire mesh. In the first, two separately formed sheets of glass, while still plastic, are brought together between compression rolls where the wire glass is supplied; one of the rolls is corrugated and the other smooth. In the second patent a process is disclosed wherein the wire is so fed that it is drawn

(*Continued on page* 129)

A. C. S. PITTSBURGH MEETING — A WAR CONGRESS

Under normal peacetime conditions Pittsburgh as the meeting place for the annual American Ceramic Society Convention would offer many points of interest to glass men because of the extensive glass activity in this area. However while the meeting scheduled to be held during the week of April 18, with headquarters at the William Penn Hotel, will not be lacking in interest from the standpoint of papers and discussions it seems there will be little or no time for plant trips or other activities outside of the sessions. Due to transportation difficulties and other problems resulting from war conditions it has been decided not to extend the meeting beyond Wednesday, April 21. In spite of the curtailment of time, The Glass Industry understands that six hundred individuals have signified their intention to attend the meeting as this issue goes to press.

While complete details of the program are unavailable at this time, General Secretary Purdy reports tentative promises of important speakers for the War Congress Session now planned for Monday afternoon.

Among the papers to be presented at the War Congress Session is a report now in preparation by the Institute of Ceramic Engineers, "Role of the Ceramic Engineer in the War Effort" by Nelson W. Taylor.

This session together with the shortened meeting period will probably necessitate a general session program on Tuesday morning, thus crowding the Division Sessions into one and a half days.

In spite of the complexities of business today, J. F. Greene, Chairman of the Papers and Program Committee of the Glass Division, has developed a program of papers which should prove both timely and interesting. There will also be a symposium on "Fining and Decolorizing" with emphasis on current necessities for substitutions. The discussions will be lead by Dr. W. A. Weyl of Pennsylvania State College and Dr. R. R. Shively of B. F. Drakenfeld Company.

The list of papers now scheduled, together with brief available summaries follow:

The Vitreous State. *By Maurice L. Huggins & Kuan-Han Sun, Eastman Kodak Company, Rochester, New York and Alexander Silverman, University of Pittsburgh, Pittsburgh, Pennsylvania.*

The difficulty of defining the vitreous state in a rigorous manner, the existence of many borderline cases and the theoretical requirements which must be met if a substance is to be vitreous are discussed.

Experimental Studies of the Temperature Gradients in Glasses of Various Colors. *By H. H. Holscher, R. R. Rough and J. H. Plummer, Owens-Illinois Glass Company, General Research Laboratory, Toledo.*

This paper is concerned with a laboratory study of vertical temperature gradients obtained in a small furnace heated over the glass surface.

A Method for Estimating the Expansibility of Glass at High Temperatures. *By S. R. Scholes and Kurt Mooney, New York State College of Ceramics, Alfred, New York.*

Molten glass fills to overflowing a measured cavity in a refractory block. Upon cooling, it leaves a depression whose volume can be measured. After correction for the volume change of the refractory, the cubical expansion of the glass is estimated.

Aging Thermometers. *By Bradford Noyes, Taylor Instrument Companies and Nelson W. Taylor, The Pennsylvania State College.*

It is shown that in the long time aging of thermometers at constant temperature the change in readings of a fixed point, such as the ice point, normally follows an exponential law, $y=a(1-e^{-mt})$. Methods are described for the evaluation of the total expected change, a and of the relaxation time, $1/m$, and of the half life period, $H=0.693/m$.

Eye Protective Glasses Go to War. *By E. I. Hettinger, Willson Products, Inc., Reading, Pennsylvania.*

A discussion of the importance of eye protective glasses in the performance of the War Program. The urgent need for uniform specifications throughout the various government agencies.

Glass Properties and the Periodic Table. *By Maurice L. Huggins and Kuan-Han Sun, Kodak Research Laboratories, Rochester, N. Y.*

In this paper, graphs are presented, showing the dependence of certain constants, characteristic of the component oxides in silicate glasses, on the atomic number of the element (other than oxygen) in the component. The curves obtained enable one to estimate, by interpolation and extrapolation, values for components for which experimental data are not at present available.

Changes of Properties of a Glass Resulting From Changes of Composition. *By Maurice L. Huggins and Kuan-Han Sun, Research Laboratories, Eastman Kodak Company, Rochester, New York.*

Structural Heterogeneity in Glass. *By Mrs. A. Winter, Research Enterprises Limited, Leaside, Ontario, Canada.*

Theoretical Aspects of the Chemical Attack of Glasses by Water. *By Aaron K. Lyle, Hartford-Empire Co., Hartford, Conn.*

Viscosity of Glass in the Melting and Annealing Ranges. *By H. A. Robinson, Armstrong Cork Company.*

Raw Materials. *By John R. Hostetter, War Production Board.*

A meeting on glass and glass products of Committee C-14 of the A.S.T.M. will be held in conjunction with the Glass Division Meeting. A definite time for the Division luncheon has not yet been fixed, but it is tentatively planned for either Tuesday or Wednesday.

The Glass Industry is advised that the Local Committee is planning a very pleasant reception for Sunday night following an illustrated lecture and demonstration by Dr. Alexander Silverman on "Postwar Glasses." Monday night will be devoted to Alumni reunions and Student Receptions. On Tuesday night there will be popular entertainment and dancing.

Despite the fact that some of the regular exhibitors are too busy this year to enter the annual exhibition of the Ceramic Camera Club, V. H. Remington in charge of arrangements states that the show will go on and that he expects it to be a good one. Arrangements have been made with the Hotel William Penn for a room for the exhibition. The Annual Ceramic Camera Club dinner is scheduled for Monday night, April 19 at 6:30.

This year subject classifications have been limited to three groups: pictorial, portrait, industrial and scientific. Anyone who is a member of the American Ceramic Society may enter prints in competition.

GLASSHOUSE GREMLINS

(A Scientific Study of)

For long years past the glass technologist has been endeavoring to explain certain defects and difficulties that are encountered in the manufacture of his product on a strictly scientific basis. At present the tendency is to explain such phenomena on the basis of atomic structure, which, as anyone can readily see, is a small thing to do. Recent developments in other fields, and by men whose only connection with glass is during a ten-day leave, have shown rather conclusively that many defects, mistakes, deficiencies, imperfections, blemishes, so forth and including etc., are due, not to any ordinary, known and explainable practical or scientific fact, but to a pseudo-protoplasmic group of bodies known as Gremlins.

According to a noted authority on the subject (Quentin Reynolds, Colliers, Oct. 31, 1942) the original abode of the Gremlins was the Highlands of Scotland and, as is now well known, they bothered no one (with the exception of a few "tight" Scots folk) until a difference of opinion arose between a few small-fry Gremlins and some members of the R.A.F. This story has been told elsewhere. Our present interest is in another branch of the Genus Gremlin, namely, Glasshouse Gremlins.

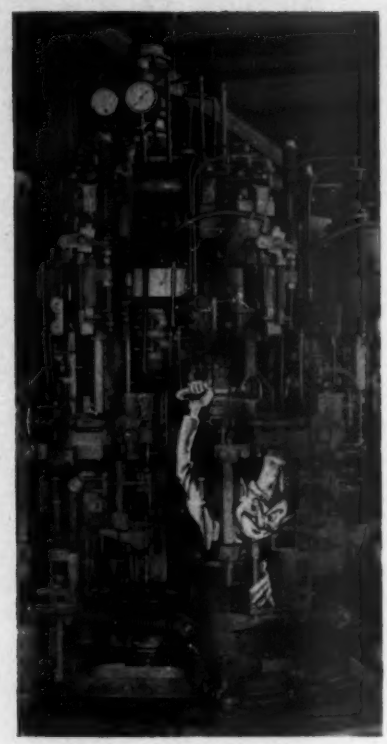
A "cursery" investigation has disclosed that it is highly probable that a group of Gremlins, their Fifinella wives and Widget offspring returning with the R.A.F. after a sweep over the low countries mistakingly hopped off near one of U.G.B.'s bottle plants and to escape detection hid in a shipment of empty, newly manufactured Vat 69 bottles. Unfortunately for the Gremlins the bottles had choked necks and as they couldn't get out they were shipped along with and in the bottles which were filled as usual and shipped to America arriving in time to be served at the 1942 meeting of the Glass Division at Absecon. How they obtained entrance into our glass plants is obvious! (It should be mentioned that the smoke in the Scotch prevented them from being seen by the custom's inspectors). Having obtained entrance and not having the R.A.F. to play their mischievous tricks upon they did what any true blooded Gremlin would do, that is, make themselves at home.

The fruits of their labors are becoming increasingly evident and, as will be shown, is of sufficient importance to warrant this special study. While the data presented herein on the behaviour of Glasshouse Gremlins is the result of a fairly extensive analysis by the "wet" method, it cannot, by any stretch of the imagination, be considered complete. It is hoped that other studies will be made. (Much of the necessary equipment will be available at the Pittsburgh meeting of the A.C.S.)

Due to the breeding habits of the Gremlins and Fifinellas (in which respect they are similar to Lepus cuniculus[1]) they are to be found in every glasshouse opera-

Happy moment in the life of a Heavy-handed Fifinella as she upsets the batch mixing operation, pulling the mixer's arm.

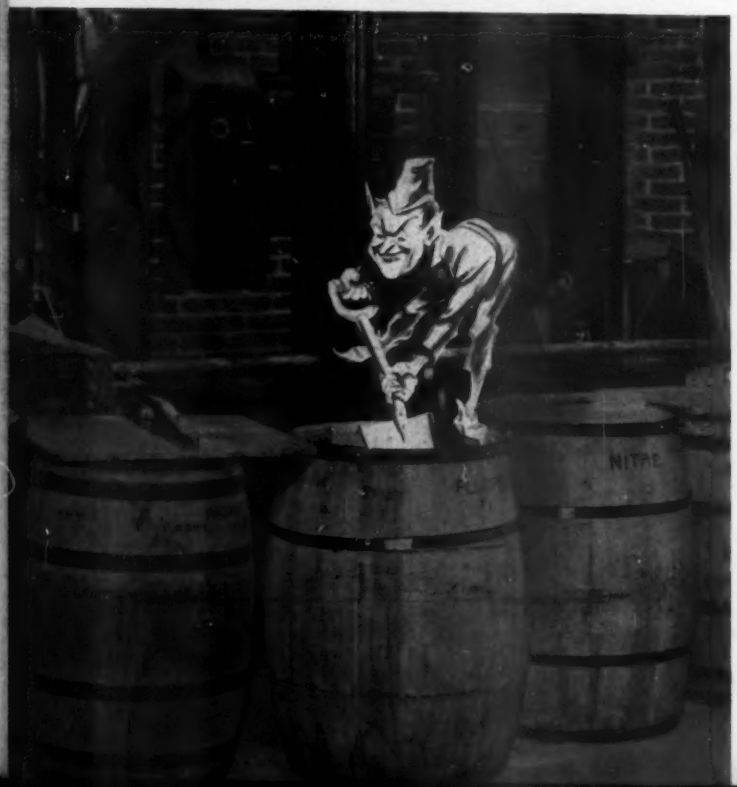
Widget tries his hand at reversing lettering on a bottle mold.



A gay Gremlin disports himself in an intricate forming machine.

tion. In the batch room for example the "Blind as a Bat" Gremlin is quite active. This character is responsible for putting the wrong material in the right bin and the right material in the wrong bin and other acts of a similar nature. His better half, commonly known as Heavy-handed Fifinella pursues a different line of endeavor being responsible for wrong batch weights and weighing errors. Due to the feminine love of color one of Heavy-handed Fifinella's happiest moments is when the bottles come out blue-tint instead of colorless as all good flint ware should be. Such a condition is due without a doubt to this Fifinella's habit of putting a little extra cobalt in the decolorizing mixture. Like all children, the little Widgets just love to play with water and by so doing cause the sand to become wet,

"Blind as a Bat" Gremlin gleefully sneaks a shovel full of fluorspar into the nitre barrel, in the batch storage room.



A Gremlin of the packing-room species plies his trade as he puts a wine bottle with wide-mouth jars as they are packed.

making the batch all balled up like mud pies, the soda caked and hard and the burnt lime run about 25 per cent ignition loss when it should be minus 5 per cent in order to correct for that foreign cullet one has just started to use. The I.Q. Gremlin spends his time separating the various batch ingredients in a manner similar to that used in the Army placement tests. This, of course, leads to an interesting batch phenomena known as segregation.

The Tank Gremlins are little devils both in mind and body, particularly in body, in order to satisfy the conditions under which they exist. This group is by far the largest and the various sub-divisions are by no means complete. One of the outstanding Gremlins in this group is Phase Rule Equi who obtains his calories by consuming various and sundry types of refractories. When he is very hungry one can expect a break through at the metal-line or the throat almost any time but especially when the management wants good old No. 5 to run "just another 30 days." When Phase Rule Equi is not satisfied with the heating system he makes it known in several different ways. If he's too hot he lets the crown drip to satisfy his humidity (relative) requirements and when he's too cold he may freeze the throat on general principles. It has been the general impression that stones in the glass were due to the above Gremlin. This is not the case, actually they are due to his Widget off-spring as they have been observed by at least one tank-teaser who reports that they were sitting on the bridgewall and were throwing stones into the glass the same as a group of small boys would do on the shore of a lake. If this single observation can be accepted as a fact, it also explains why waves are found in blown ware. In spite of the centrifuge technique, surface tension studies and the ring section method, cords in glass are definitely due to the female

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Decolorization and Fining in the Absence of Arsenic

Editor's Note: Arsenic for some time has been entirely unavailable to glass manufacturers. On January 1, 1943, niter was denied to the glass container industry and reports emanating from Washington indicate that further curtailment may be necessary unless manufacturers of certain types of glass and tableware, for example, hold their consumption of niter to 1940-41 levels.

The sudden elimination of any batch constituents present difficult problems to the chemist in the glass plant even when substitutes are known. Although the last year was fertile with problems of this kind, the lack of arsenic and niter, was regarded as one of the most obnoxious inconveniences in the medium sized glass plant.

Since the precise knowledge of the function of a particular constituent should precede any successful substitution, this journal has tried to assist the glass industry by inviting several glass technologists to comment on the specific part played by various key materials in the composition of glass. A series with this purpose was started in 1942, and is being continued. As far as arsenic and the problems of decolorization are concerned, reference may be made to several articles on arsenic and sulfates in this series.

On the other hand, the perusal of papers describing facts ruling the function of arsenic and, more generally, the mechanism of decolorization and fining may seem both too technical and too time-consuming to men who are bearing the grave responsibility of leading a medium sized glass plant through the period of emergency.

The aim of this brief paper is to summarize those facts of immediate and practical importance which may be derived from the technical literature and can be applied to the present problem without closer study of the exhaustive technical information.

Arsenic has been used for a long time to improve the color of and to accelerate the removal of seeds from the glass. The first function is called its decolorizing effect and is due to the partial oxidation of deeply colored iron to a less colored, more oxidated stage. The first function is, therefore, based on the fact that arsenic makes oxygen available. The second function is called the fining effect, and is based on the fact that arsenic makes gas available in the later stage of the melting process. Gases originating in the melting process, e. g., CO_2, SO_3 will be removed most easily if they can diffuse into bubbles consisting of any other gas. The development of such a gas is helpful as long as it does not interfere with the task of oxidizing the deeply colored lower oxidation stage of iron.

For all practical purposes only oxygen can be used simultaneously for the two functions of decolorization and fining.

Any substitutes of arsenic consequently have to provide oxygen at a late stage of the melting process. As a matter of fact, the true condition is a little harder: they have not only to provide oxygen but a substantial and satisfactory volume of oxygen at a substantial and satisfactory pressure, and at the right moment.

How Does Arsenic Do It? Why Niter?

In the presence of alkali, arsenic is capable of doing these things in the way we want it. At relatively high temperatures and in the presence of alkali, the pentavalent arsenic decomposes to trivalent arsenic giving off oxygen:

$$As_2O_5 \longrightarrow As_2O_3 + O_2$$

This is only possible if As_2O_5, the pentavalent arsenic has actually been present at low temperature. For this purpose, enough oxygen has to be available in the low temperature stage to oxidize any As_2O_3 present.

This is accomplished by the simultaneous use of nitrates and arsenic. The nitrates, for instance KNO_3, oxidize all As_2O_3 to As_2O_5 in the earlier stage of the melt.

If niter is absent, arsenic still may work to some extent because at lower temperatures, As_2O_5 oxidizes itself forming $As_2O_5 + As$:

$$5\ As_2O_3 \longrightarrow 3\ As_2O_3 + 4\ As$$

This reaction, however, endangers the color of the glass by the formation of elemental arsenic.

Why Not Niter Alone?

If niter delivers oxygen, why do we bother with arsenic? Because niter gives off oxygen at so early a stage in the melt that the fining process would not profit at all. The arsenic has the function of bringing niter's oxygen to the fining stage. Thus arsenic without niter, and niter without arsenic are of little use.

Antimony for Arsenic

We want oxygen at a late time, of substantial volume and pressure. If we have to omit arsenic, the present situation permits the consideration of antimony. How does antimony compare?

(a) In principle, antimony functions like arsenic.

(b) Antimony requires nitrates more urgently than

(*Continued on page* 127)

SUMMARY

YIELDS

	Oxygen	*At high Temp.*	*Volume*	*Pressure*	*Only with:*	*Only without:*	*Iron color*
Arsenic	Yes	Yes	High	High	Nitrate	—	Improved
Antimony	Yes	Yes	Less	High	Nitrate (or peroxides, chlorates)	—	Less improved
Niter	Yes low temperature	No	—	—	Arsenic or Antimony	—	Improved
Peroxides-Chlorates Chlorates	Yes	No	—	—	Arsenic or Antimony	—	Improved
Cerium Oxide (cost factor limits amount)	Yes	Yes	High	High	—	Arsenic	Danger of Yellow
Sodium Sulfate: (dangers: immiscibility, sulfides)	Yes	Yes	High	Low	—	—	Improved, if enough

THE ROLE OF SODIUM SULPHATE IN GLASS MANUFACTURE

By WOLDEMAR A. WEYL*

PART III

The Formation of Sulphates under the Influence of the Furnace Atmosphere

Alkali chlorides react with SO_2 and O_2 in the presence of water vapor to form alkali sulphates and hydrochloric acid.

$$2\ Na\ Cl + H_2O + SO_2 + \tfrac{1}{2}\ O_2 = Na_2SO_4 + 2\ H\ Cl$$

This reaction has been used by Hargreaves to convert salt into sulphate in a technical scale. The temperature requirements are low, around 500°C. The product is of a high quality, its iron content in particular is very low. The English plate glass industry in the past has absorbed large quantities of Hargreaves' sulphate. In France the St. Gobain glass works had their own alkali plants where sodium sulphate was produced by this process.

The reaction is not restricted to alkali chlorides, but other alkali compounds such as the silicates react similarly. V. Takats[28] studied the formation of sulphates when air containing 5% SO_2 was passed over silicate glasses. From Table II, we see that the reaction starts at relatively low temperature so that glasses react already far below their softening points.

TABLE II.

Composition of Glass	Sulphate formed at the temperatures					
	300°C	350°C	400°C	450°C	500°C	540°C
Na_2O, 2 SiO_2	9.0%	12.2	22.7	48.4	54.3	60.9
Na_2O, 3 SiO_2	5.5	4.3	5.0	4.8	5.2	5.3
Na, O, 4 SiO_2	3.0	3.0	3.7	3.5	3.7	2.9
PbO, SiO_2	0.5	0.9	1.6	3.1	6.9	10.9
PbO, 2 SiO_2	1.1	0.5	0.7	1.0	0.8	2.0
PbO, K_2O, 4 SiO_2	1.1	1.7	3.6	8.4	15.5	30.2
PbO, 3 B_2O_3, SiO_2	0.8	0.7	0.7	2.4	12.7	15.2

Sulphate formation is more intensive with potassium silicate than with the corresponding sodium silicate glasses. Lithia glasses have been found to be less reactive. Besides alkali, there are other glass constituents like lead oxide which may yield sulphates when exposed to a sulphur dioxide-oxygen mixture. The data in Table II do not represent final or equilibria values but allow us to compare the reactivity of different base glasses. They were obtained by passing five liters of air containing 5 Vol. % SO_2 over a sample of the powdered glass, determining the amount of sulphate by analysis and expressing it as a fraction of the sulphate which would have formed when the total amount of basic oxides had been converted. A value of 50% means, therefore, that half of the Na_2O or PbO had changed into the sulphate and the rest remained silicate. Sulphate formation, due to a reaction of this type, had been observed in industrial kilns when the furnace atmosphere contained both SO_2 and oxygen. Leading ceramists like Seger [16], Mellor[29], and Watts [30] found that this reaction is the primary cause of several defects they encountered in glazing white ware bodies. The large surface exposure, the low temperature, and the basicity of glazes, as compared with glasses, all work in favor of sulphate formation. Soda-lime glasses are less likely to form sulphate, especially not during the melting and fining period. At lower temperature, however, sulphate formation is very common. I. I. Kitaigorodsky and I. A. Scholnikov[31] report their experience with Fourcault glass tanks where salt water formation occurred quite frequently in the drawing chamber. Usually the melting compartment of the same tank remained free of gall except when the temperature dropped accidentally below the usual range.

It has been found experimentally by H. Salmang and A. Becker[32] that sulphate formation requires the presence of free oxygen. Jebsen-Marwedel confirmed this result with observations in a glass plant.

In the old type of annealing furnace, where the glassware was exposed to the open flame of gas or coal, the ware was found covered with a white dust of sodium sulphate. This interaction of sulphur dioxide, oxygen, and the glass surface, had a distinctly beneficial effect. The surface became richer in silica, poorer in alkali, and consequently, the resistivity was increased.

The Improvement of Chemical Resistivity Through Sulphur Dioxide

The glass workers who first paid attention to the dust film developed on the glassware during annealing thought of it only in connection with proper annealing. It was customary in many plants to correlate the formation of the bluish-grey dust with the temperature range sufficiently high to remove mechanical strain. When the lehr was too cold a black sooty deposit was formed rather than a bluish gray one. G. Keppler[33] called attention to the fact that proper annealing improves the chemical resistivity of a glass between 10 and 20%. He further observed that repeated annealing in an open lehr, where the glass surface was exposed to the flame gases, was more effective than an identical heat treatment in a closed muffle. He explained this observation by the extraction of alkali from the glass and formation of a more siliceous surface layer.

A. Cousen[34] and C. J. Peddle[35] showed that the alkali extraction figures were decreased by annealing under conditions by which sulphate bloom is produced. For glass bottles with narrow necks, where none or not enough of the furnace atmosphere had access to the inner surface, the improvement was considerably less. Once this effect was known, various patents were taken out with the aim to provide a furnace atmosphere with an "artificial" sulphur content or dropping sulphur into the bottles before annealing.

*Prof. of Glass Technology, State College, Pennsylvania.

The chemistry of this action of sulphur is relatively simple. The reaction taking place at the glass surface corresponds to that of the Hargreaves process. In order to provide a more resistant surface skin, it is sufficient to extract the alkali from a layer which is only a few molecules thick. The diffusion speed of alkali during the softening range permits the glass to react to a depth of about 1/10 mm. Withdrawing alkali from the surface produces a gradient in alkali concentration which causes the alkali to diffuse towards the surface. Temperatures above the softening point of the glass are undesirable even if the shape of the ware would allow such treatment, for at high temperatures, the removal of alkali leads to devitrification. The surface of the ware looses its gloss and becomes rough. The glass maker calls this defect, not very correctly, "burnt-in bloom."

Improvement of Mechanical Properties Through Sulphur Dioxide

Less obvious is the improvement of mechanical properties by exposure of the ware to a sulphur dioxide containing atmosphere. J. B. Murgatroyd[36] observed that glass containers became more resistant to thermal shock when exposed to a sulphur containing atmosphere during annealing. Also the impact strength of bottles was found to improve about 15% and the bursting pressure to increase between 15 and 20%. C. J. Peddle[35] too, proved that the mechanical properties of bottles such as determined by pressure tests, thermal shock tests, and impact tests could be considerably improved by annealing in a furnace atmosphere containing a "natural" or "artificial" sulphur content. The effect of a surface treatment on the mechanical properties of glass is not unknown. We have evidence that etching the surface of fibers made from fused silica results in an improvement of their tensile strength. In the case of pure silica a change in the chemical composition of the surface layer is obviously impossible. In order to understand these phenomena we have to realize that rupture nearly always starts from the surface. Uneven surfaces or cracks of molecular dimension form the centers of highly strained areas as soon as a piece is subject to thermal shock or tension. Thermal treatment, especially when combined with a chemical reaction results in the healing of these cracks and improving the mechanical properties. The chemical composition alone would not account for the great changes which have been observed.

In order to get more information on this subject and provide data which were more accurate than those obtainable from testing bottles, J. Boow and W. E. S. Turner[37] used strips of sheet glass of definite size and known composition. The specimens, 10 cm. long, were cut from flat drawn sheet glass in a way that the length of the specimen was at right angles to the direction of the drawing of the sheet. The strips were ground to a width of 8 mm and polished to remove surface cracks which otherwise would impair the reproducibility of the rupture test. Table III brings some of their results. Heating the specimens for two hours in air already improves the modulus of rupture, especially when the temperature reaches the softening range. There can be no doubt that this improvement must correspond to a low temperature "fire-polish" and is due to a decrease in surface flaws and submicroscopic cracks which heal by the heat treatment. The data show, however, that especially at 550°C the sulphur containing atmosphere gives much better results than air alone. The last column gives the improvement in strength through sulphur dioxide as compared with sulphur free air. Boow and Turner came to the conclusion that the improvement in mechanical properties can not be due to the neutralization of the surface alkali alone but to the neutralization of that which is brought to the surface by diffusion from the body of the glass.

TABLE III.

Temperature	Air	Specimen heated for two hours in SO_2 containing atmosphere		
	Modulus of Rupture	mg SO_3/100cm^2	modulus of Rupture	Improvement in Strength
20°C	906	...	....	....
490	968	1.7	960	0.8%
530	1009	2.8	1087	7.7%
550	1085	3.3	1269	16.9%
580	1160	3.5	1288	11.0%

Disadvantages and Defects Connected with the Use and the Formation of Sulphates

In previous chapters we dealt with the beneficial influence of sulphates on the melting, fining, and decolorizing of glass. We heard further that the reaction of the finished glassware with a sulphur dioxide containing atmosphere improves the chemical resistivity and the mechanical strength of the ware. In this chapter, we shall discuss limitations of using sulphate and troubles which may arise when the sulphate content of the glass is not properly controlled.

(a) How to Determine the Optimum Conditions for the Use of Sulphate

There is no doubt that the success of the melt and the quality of the resulting glass depends to a great extent on the percentage of alkali introduced as sulphate and the sulphate to carbon ratio. It is unfortunate that we cannot use one of the chemical equations and simply calculate the appropriate amount of carbon which should be added to our glass batch in order to obtain the best results. An unavoidable loss of carbon through burning and the participation of carbon monoxide from the furnace atmosphere make it necessary to use corrections and to change the theoretical carbon addition. The glass melter has to gather experience and develop his own batch composition which might even vary from one melting unit to the other. Sometimes in the same furnace the pots in different positions have to be charged with slightly different batches, in order to produce the same results.

H. Jebsen-Marwedel and A. Becker[38] give an instructive description of their own approach to find out the best conditions by small scale laboratory melts. The optimum consists of a compromise between the meltability including the avoiding of scum and gall, the fining properties, and the color of the glass.

500 g. melts of the desired soda-lime-silica glass were carried out in crucibles using a weakly reducing atmosphere (1 to 2% CO) and a temperature of 1350°C.

In six series, increasing amounts of Na_2O were introduced in the form of sulphate. The minimum amount was 1%, the maximum, 6%. Carbon was added to the batch so that within each series the carbon content was raised from 2 to 10% of the weight of the sulphate corresponding to the following steps: 0.5, 1.0, 1.5, 2.0, 2.5 mols. Five steps within each of the six series require 30 melts altogether. These melts were inspected by sawing off the bottom of each crucible. Now the samples were arranged in a diagram using the Na_2O content as ordinate and the carbon ratio as abscisse. Figure 5 gives the results of these experimental melts.

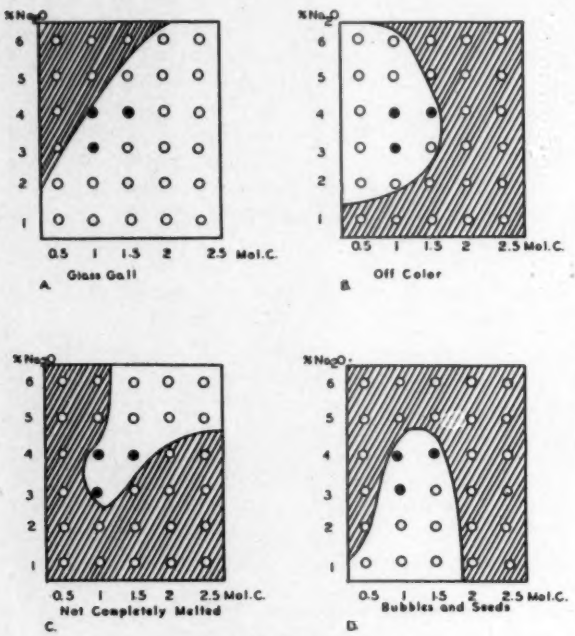

Figure 5

A. All melts of the upper left corner, that means, those containing the large amounts of sulphate with insufficient addition of carbon, produced glass gall and consequently, are out for practical purposes.

B. Light colors, that means efficient decolorization, is favored by high sulphate and low carbon content. The majority of compositions did not meet this requirement of color. Only 12 melts were considered satisfactory.

C. Some glasses were not homogeneous. The sand had not completely dissolved and scum formation was observed. From the view point of homogeneity, only 7 batch compositions were found to give satisfactory results.

D. Only 9 from the 30 glasses were free from bubbles and seeds. The rest had to be discarded.

Looking over the four diagrams we see that all glasses with the exception of three have one defect or another. These three glasses represent the composition range which gives the most favorable result. The exact ratio or percentages will, of course, vary with the melting conditions, but the work of Jebsen-Marwedel and Becker demonstrates how the glass melter can find out his optimum conditions and balance his batch so as to avoid the four main defects: unmelted material, gall, off-color, and seeds.

(b) Formation of Seeds Due to Variations of Furnace Atmosphere

In our previous discussion we have agreed on the importance of the furnace atmosphere and have learned how a reducing or an oxidizing atmosphere affects the sequence of reactions taking place in the melting glass. We have silently assumed, however, that the furnace atmosphere remains constant and does neither vary with the time nor section of the furnace. This is a simplification which for many cases does not hold true. Every glass melter knows that there are certain regions in his furnace where the atmosphere is more oxidizing or reducing than others. He also had experienced that certain fluctuations in the composition of the furnace atmosphere were unavoidable. Some glasses like carbon amber, which are particularly sensitive to changes in the furnace atmosphere, are known to become seedy during certain working hours, especially when the furnace temperature has to be slightly raised.

In the chapter dealing with the chemical reactions taking place in a sulphate containing glass batch we learned that sulphates can be present even in glasses containing sulphides or polysulphides. Under strongly reducing conditions, for instance, in the carbon amber glasses sulphide formation leads to brown colors. This does not necessarily mean that in such a glass no more sulphate could be present. Jeben-Marwedel[39], for instance, found sulphate to be present in a carbon amber glass. The simultaneous presence of both compounds causes a gradual liberation of sulphur dioxide from the melt.

$$3\ Na_2SO_4 + Na_2S = 4\ Na_2O + 4\ SO_2$$

In other words the simultaneous presence of sulphates and sulphides represents a potential source of bubbles and seeds. It is not uncommon that in a certain part of the tank where the flame touches the melt, sulphides are produced by a reduction of the SO_3 content of the glass. The currents in the tank bring the brown sulphide containing glass in contact with the unreduced parts of the melt which are still rich in sulphate. At the interface of both glasses seeds are formed which contain sulphur dioxide only and which, consequently, cannot be absorbed on cooling. Only seeds containing SO_2 and O_2 both can be expected to be reabsorbed when the glass cools from the fining to working temperature.

$$Na_2O + SO_2 + \tfrac{1}{2}\ O_2 \longrightarrow Na_2SO_4$$

The same phenomenon, can be observed when the furnace atmosphere as a whole changes from oxidizing to more reducing conditions. The defect of "delayed seeds" that means, of gas bubbles which form after the general gas evolution has ceased and the melt was fined, are often the consequence of the sulphate content of the glass and variation of the furnace atmosphere. In pure soda batches this defect occurs when a fuel is used which produces sulphur dioxide and causes sulphate formation.

(c) Refractory Attack

Another source of trouble in using sulphates may arise from the volatility of the sodium sulphate. J. S. Gregorius and W. A. Mahaffey[40] when discussing the question: whether the corrosion of the superstructure of a tank is caused chiefly by the dust rising from the batch or whether it is more due to the vapor of certain glass con-

stituents, determined the condensible vapors in different parts of a large window glass tank. It was found that when using a sulphate containing batch 96 to 97% of the vapor which could be condensed consisted of sodium sulphate. Minor amounts of sodium chloride were present in those parts where the temperature was relatively low.

This observation was later confirmed by laboratory experiments carried out by E. Preston, W. E. S. Turner, and H. Laithwaite[41]. These authors prepared four soda-lime-silica glasses containing 16% Na_2O and between 0.31 and 0.83% SO_3. Samples of these glasses were held in an oxidizing atmosphere at temperatures from 1300 to 1450°C. Comparisons of the total volatilization loss with the sulphate content proved that the presence of SO_3 favored volatilization of the alkali. In the particular glass composition 0.8% SO_3, approximately doubled the alkali loss. There can be no doubt that some of the sulphate vapor collects in the bricks of the superstructure and contributes to the refractory corrosion. Jebsen-Marwedel[42] mentions a case where a brick of the working end of the tank having a temperature between 1100 and 1150°C became saturated with molten sulphate. After cooling, hydration of the sulphate caused the brick to burst.

In the absence of reducing agents sulphate is less corrosive than soda ash. This is illustrated by an experiment described by O. Bartsch[43]. He made a crucible out of fireclay, burnt it at 900°C and then used it to melt pure sodium sulphate. No attack could be noticed below 1200°C, but at 1250°C the crucible started to blister and crumble, the bottom fell off and soon nothing was left but a heap of leafy material.

Whether or not the sulphate content of a soda lime glass increases its corrosive properties has not yet been definitely established. It seems that there is no major difference in this respect between a soda or a sulphate glass.

G. Gehlhoff, H. Kalsing, K. Litzow and M. Thomas[44] studied the corrosive action of the different batch constituents on various refractory materials. They came to the conclusion that the difference between sulphate and soda attack is brought out chiefly at high temperature. Above 1200°C sulphate exerts a stronger action on an aluminous refractory than soda ash. Siliceous refractories seem to be better suited for sodium sulphate.

The writer feels, that the porosity of a refractory is much more important in this respect than the chemical composition. The attack of a refractory through soda ash will soon lead to a viscous melt which seals the pores of the refractory and slows down corrosion. This is not so in the case of sodium sulphate. Its immiscibility in silicate melts prevents it from becoming diluted and viscous. It preserves its property to penetrate into the finest pores of a refractory brick where it is a source of undiluted alkali right in the interior of the refractory. Wherever we have to expect attack of sodium sulphates in the liquid or in the vapor state we should think of low porosity of the refractory material as the first requirement.

(d) Sulphate in the Finished Product

There are scarcely any cases known, where the sulphate content of a glass can be considered a source of trouble. In times when no special borosilicate glasses were used in the chemical laboratory the SO_3 given off by glass containers must have interfered with some accurate analytical work. C. Bunge[45] complains about sulphate formation in burettes which were allowed to stand with 1/10 normal $Ba(OH)_2$ solutions. Of course the analyst has a right to know what his glassware contains and how it responds to the different treatments. Bunge suggests to apply the same procedure to laboratory glassware which is customary with chemicals and reagents for analytical purposes. Each set of apparatus glass or laboratory ware should be accompanied by a slip, indicating the constituents which might go into solution and interfere with the analysis.

J. N. Coward and W. E. S. Turner[46] who made extensive studies on the clouding of soda-lime glasses in an atmosphere containing sulphur dioxide discuss also the question if the SO_3 content of a glass might interfere with lampworking. There is no doubt that hydrogen diffusing from the flame into the glass might cause blistering but it seems that the sulphur content of the flame contributes more to this defect than the sulphate content of the glass. Sulphates in the glass are less reactive than other compounds such as arsenates and antimoniates.

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FIBER GLASS DEVELOPMENT REVIEWED IN ADDRESS BY ARMY'S MAJOR KEISER

The development of glass fiber and its many uses during the present war program was discussed by Major Hubert D. Keiser, Services of Supply, Resources and Production Division, United States Army, in an address delivered before a meeting of the American Institute of Mining and Metallurgical Engineers on February 15.

Major Keiser described in detail the applications of this new glass material for the Army and Navy, and said in closing that "it would seem reasonable to state that a new basic material has been brought into being, and that a new and significant industry of enduring importance has been created by the development of the American processes of forming fibrous glass. . . . It would be folly to think that the progress made in a decade would suddenly stop. Continuity of research and development work by a large and virile organization assures that new products and new uses will appear after the war."

• The Wartime Packaging Conference and Exposition, sponsored by the American Management Association, will be held at the Astor Hotel, New York City, April 13 to 16.

ZINC OXIDE IN GLASS

By NORBERT J. KREIDL*

PART II

The use of zinc oxide in apparatus glass, where it contributed to excellent chemical and thermal resistivity, was extended to more specific glasses where a definite and unusual performance in connection with thermal properties was required. Examples of such special compositions follow:

(a) Thermometer Glass

Thermometer glass has not only to possess low thermal expansion but also to meet severe tests with respect to unchanged dimensions over a longer period of time. Very peculiar alterations of this type called the "after effect" had been observed at the time of early thermometry and for purposes of scientific exactness a special thermometer glass which did not show these secular changes had to be developed. The use of soda or potash alone rather than in combination with each other was found to be the most important composition requirement; but it was also found that zinc oxide could replace a large part of the lime to advantage, for instance in an early experimental thermometer glass of 1885[21] (Table XI). This glass represents one of the earlier experimental attempts finally leading to the excellent "normal" thermometer glass, which also contains zinc[5]. (Table XII.)

(b) Thermos Bottles

The composition of a thermos bottle[22] is given on Table XIII.

(c) Alkali-free Tubing

In one of Schott's alkali free glasses the fluxing properties are provided by barium oxide. In combination with zinc oxide sufficient fluxing was accomplished without devitrification[23].

(d) Water Gauge Glasses

Zinc oxide is employed to advantage in water gauge glasses. A modern water gauge glass contained, for instance, 8 per cent ZnO[24] (Table XIV.)

The function of special constituents in such a glass is to improve:

(aa) resistance to pressure, in cold and hot condition

(bb) thermal shock resistance

(cc) chemical resistivity

In hot use the interior of the tube is exposed to essentially higher temperature than the exterior. The inner wall is under compression, the outer, under tension. Since poor annealing causes the opposite effect, well annealed glasses were found to fail more easily. Furthermore, thermal shock was caused frequently by snow, rain and draft. Once these conditions were recognized[25] special glasses were developed in three directions:

(aa) Aluminoborosilicate glasses of low thermal expansion which stood three times the pressure and possessed six times the resistivity of glasses formerly used. Frequently zinc oxide was added to these glasses ("Durax," "Durobax")[26]

(bb) Hardening by quenching

(cc) Compound Glass, as described in the following paragraphs.

*Ceramics Department, Pennsylvania State College.

(3) "Compound" Glass

In 1891 Schott[27] had successfully attempted to create the desired distribution of stress by another method than quenching. In order to compensate for the fact that the inner layer is subjected to larger expansion due to its higher temperature, the tube was cased using the two different glasses in a way that the thin inner glass had a low coefficient of expansion. Thus the total expansion of the inner surface of the glass (low coefficient x large increase of temperature) and outer surface (high coefficient x small increase of temperature) was balanced. This cased glass was called "compound" glass and zinc oxide was used in the batches. One example of a glass which in the Schott Herschkowitz test[25] was 3 times as resistive and stood higher pressure than the usual glasses, is given in Table XV.

TABLE XI

Early Thermometer Glass (1885)

SiO_2	54
K_2O	16
ZnO	**30**

TABLE XII

"Normal" Thermometer Glass

Al_2O_3	3.8
B_2O_3	.9
SiO_2	66.6
Na_2O	14.8
MgO	.2—
CaO	7.2
ZnO	**6.2**
MnO	.3

TABLE XIII

A Thermos Bottle Glass

Al_2O_3	5
B_2O_3	11.2
SiO_2	62.4
Na_2O	8.2
ZnO	**12.8**

TABLE XIV

Water Gauge Glass

B_2O_3	4.0
SiO_2	72.
Na_2O	10.0
MgO	4.0
CaO	2.0
ZnO	**8.0**

TABLE XV

Compound Glass

Al_2O_3	3.5
SiO_2	73.5
Na_2O	10.5
CaO	7.
ZnO	**5.**
MnO	.2
As_2O_3	.3

(4) Stabilized Phosphate Glasses, UV-Transmitting Glasses

Phosphate glasses, the properties of which have been found desirable for optical and other special purposes, were found deficient in resistivity for a long time until their stabilization with alumina, boric acid, and other selected additions was accomplished[28].

The function of the Al^{+++} ion has been emphasized in this respect, both from a practical and theoretical viewpoint, and it could be shown how the Al^{+++} ion enters the position of a P^{5+} ion in the structure of a phosphate glass. Zinc ions doubtless are capable of assuming a similar role; evidence may be found in glasses developed in industrial laboratories.

The very low melting resistive phosphate glasses of high alkali content, invented by Grimm and Huppert[29], frequently contain zinc oxide. One example is listed in Table XVI. In later glasses of the I. G. Company[30] which

TABLE XVI
Resistive Phosphate Glass (Grimm and Huppert)

K_2O	24.2
ZnO	7.
B_2O_3	6.
Al_2O_3	26.2
P_2O_5	36.6

probably represent the continuation of the work of Grimm and Huppert, B_2O_3 was partially replaced by ZnO in a systematic way. Invariably the resistivity to chemical attack was increased and the softening temperature remained low. This is exemplified by the composition and the softening point of two glasses, one of which is free of zinc oxide, while in the other, a part of the boric acid is substituted: (Table XVII) The first glass, zinc free, exhibited a weight loss of 66 mg. in the same resistivity test wherein the second zinc glass lost only 28 mg. This zinc glass was the most resistive glass of the series.

Calcium metaphosphate[31] and barium metaphosphate glasses are the most important glasses of high ultraviolet transmission and zinc will be an important constituent wherever their improved stability is attempted.

TABLE XVII
Composition and Softening Points of Phosphate Glasses with and without Zinc Oxide (I. G. Color Combine)

	Zinc Free Glass	Zinc Glass
K_2O	11	11
Na_2O	16.5	16.5
Al_2O_3	23	23
B_2O_3	9	5
ZnO	....	**4**
P_2O_5	40.5	40.5
Softening Point	377°C	357°C
Resistivity expressed in mg. weight	66	28

(5) Zinc Crown

Zinc oxide increases the refractive index, when replacing Na_2O. At the same time it increases[32 33] the dispersion and the so-called v value $\left(v = \frac{n_D - 1}{n_F - n_C}\right)$ which is a measure of the relation between index and dispersion. If dispersion and v value both rise it means that the refractive index increases more than the dispersion.

All divalent oxides except PbO increase the v value when replacing Na_2O. The correction of lenses depends chiefly on the development of glasses which have a relation between dispersion and refraction different from that of the lead glasses and soda-lime glasses. The barium glasses with a relatively low dispersion for relatively high indices were found to be most suitable, while the majority of other glasses exhibit nearly the same relationship.

Within the series of divalent elements, zinc causes the v value to rise less than any other one. The dispersion decreases when BaO, less so when SrO and MgO replace Na_2O; zinc increases it, but less than lead and CaO.

If silica is replaced all divalent elements increase the dispersion and decrease the v value; that is, the dispersion increases more rapidly than the refractive index. Here again, with PbO leading CaO following at a distance and BaO exhibiting this typical behavior least ZnO has an intermediate position close to that of SrO[32]. In high concentrations it approaches the effect of BaO.

The zinc crowns, with indices between 1.51 and 1.53 and v values of 55-60 lie adjacent to crowns quite apart from the heavier barium crowns in th v—n_D fields characteristic for optical glasses.

(6) Barium Crowns and Flints

High barium glasses devitrify and show other characteristic deficiencies. Zinc oxide is used in many optical glasses of considerable barium content to mitigate these difficulties and to modify their optical properties. Its compatibility with BaO in optical behavor is useful in this respect, the imparted chemical stability is very desirable. Both the lead containing barium glasses of high index (barium flint) and the lead free barium crowns frequently contain ZnO.

One of the two first barium glasses reported in Abbe's letter of Oct. 7, 1881 to Schott, which announces the discovery of barium crowns and flints, contains a considerable amount of zinc oxide. (Table XIX)

(7) Optical Zinc Glasses Free of Silica

ZnO and B_2O_3 in combination with each other and other constituents form an interesting field of glasses of relatively high v values for high n_D. That means their dispersion is relatively low for the indices obtainable.

TABLE XVIII
Barium Crowns and Flints

	Al_2O_3	SiO_2	Na_2O	K_2O	CaO	BaO	PbO	ZnO	As_2O_5	Sb_2O_3
Heavy Barium Flint (Schott) 4534	....	42.8	.7	7.5	....	10.8	32.6	5.1	.5	....
Barium Flint[38] Pgh. Plate Co.	....	64.5	....	6.2	....	10.2	9.7	9.2	....	....
Light Barium Flint[34] Chance Bros. 4469	.2	49.3	3.2	9.5	.3	27.2	.7	8.6	.1	.8
Heaviest Barium Crown[35] Schott O 2236	2.5	32.8	....	....	....	42.3	....	9.2	.5	....
	B_2O_3									
Heavy, for bifocals	6.75	38.5	....	1.7	5.2	36.1	.9	7.9	.7	....
Barium Crown Schott[37] 0227	3.	58.7	3.	10.	....	20.	....	5.	....	....

An old borate flint glass[34] was composed as shown in Table XX. Glasses very high in zinc borate were made available by Tillyer and Moulton[39] who discovered that they can be stabilized with beryllium oxide.

In combination with acidic constituents of high atomic number (Titania, Molybdic Acid, Vanadum Pentoxide, Tungstic Acid) zinc was used in the development of optical glasses of high refractive index[40].

TABLE XIX

Early Barium Glass (1881)

Glass #615

SiO_2	54
K_2O	25
ZnO	**11**
BaO	10
n_D	1.533
Dispersion	.0094

TABLE XX

Old Zinc Borate Glass

Al_2O_3	12
B_2O_3	54.6
Na_2O	3
ZnO	**12.**
PbO	18.
As_2O_3	.3

(8) ZnO as a Minor Addition to Tank Glass

Most of the glasses described in the first seven sections contained considerable amounts of zinc oxide. Zinc oxide is frequently used as a minor addition in order to balance devitrification and chemical attack with meltability. It would lead too far to list examples of glasses containing less than 5 per cent ZnO but it may be useful to reminisce on the experience with window glass after the introduction of the Fourcault process.

Devitrification was by no means unusual when one tried to use the composition of earlier process window glass in the Fourcault machine. In addition to the effect of working properties, the introduction of magnesium oxide was very effective against devitrification, because the liquidus temperature of glasses containing several per cent MgO was definitely lower than that of the pure soda-lime glass, and, being about 950°C, definitely on the lower side of the working temperature. Such Fourcault glasses had the following typical composition:

SiO_2 71, Al_2O_3 1, CaO 8½, MgO 3½, Na_2O 14½-15.

The resistivity of this glass was not quite satisfactory. J. M. Muehlig[41] who introduced the Fourcault process in the Czechoslavakian plants reported some of his systematic alterations and their effect at a meeting of glass technologists. The addition of B_2O_3 in the composition area of desirable viscosity proved insufficient to obtain the required resistivity. Barium containing glasses devitrified too easily. With one per cent of zinc oxide, however, a remarkable decrease of the temperature of devitrification together with improved chemical resistivity and good workability had been obtained.

(9) Lead Substitution

In Europe special glasses containing PbO and B_2O_3 were replaced by zinc glasses when the former constituents became unavailable[42]. An example of a machine drawn glass tubing is given in Table XXI. The substitution is bound to result in higher softening point and lower expansivity. Glasses of this type were the basis for the development of glazes free of lead and boron[43]. The use of zinc oxide in lead free glazes containing boric acid is customary. Similarly zinc oxide is a minor constituent of complex glass enamels which have to fulfill unusual combinations of properties in modern illumination[44]. (Table XXII.)

(10) Zinc Oxide in Sulfide and Selenium Glasses

(a) General

The role of Zinc oxide in sulfide glasses is more important than is generally realized. Especially the effect of ZnO in colored glasses containing sulfur and selenium was known since the discovery of the selenium ruby and had been called that of a stabilizer, an adequate but indefinite designation. The strict validity of the efficiency of ZnO in selenium ruby was carefully investigated by Wekerle[45]. The destructive effect of zinc oxide on the so-called carbon amber glass[46] could not be correlated easily with this stabilizing effect in the cadmium sulfoselenide or selenium ruby glass. The carbon amber color obtained by the addition of carbonacious materials is due to the formation of sulfides by the reducing effect of the carbon on sulfates, which are present in every glass batch, more or less deliberately. According to Weyl[47], the stability of sulfur (and selenium) in glass is greatly increased by the zinc which participates in the silicate glass structure but simultaneously, in contrast to silicon, has a strong affinity to sulfidic sulfur.

TABLE XXI

Machine Drawn Glass Tubing

SiO_2	61.5
BaO	11.0
ZnO	**7.0**
Al_2O_3	.5
B_2O_3	8.0
MgO	.7
CaO	1.3
F_2	2.0
Na_2O	7.0
K_2O	11.0

TABLE XXII

Enamel for Lamp Bulbs
(Thomson Houston Co. Ltd.)

SiO_2	19
B_2O_3	41.6
Al_2O_3	1.
Na_2O	1.5
K_2O	3.
Li_2O	2.8
Sb_2O_5	1.
BaO	11.3
ZnO	**3.8**
CaO	4.7
CaF_2	5.6

This explains the "stabilizing" action of zinc oxide in the selenium ruby glass, where the sulfur and selenium is preserved for the final formation of the desired colorant, cadmium sulfoselenide. Excess of zinc with respect to sulfur leads to colorless zinc sulfide. In the carbon amber with its small sulfide concentration the presence of zinc due to its affinity to sulfur, changes the yellow alkali sulfides to colorless zinc sulfide.

(b) Selenium Ruby

On this basis the majority of commercial selenium rubies, especially those less sensitive to discoloration under heat treatment, contain large percentages of zinc oxide; some examples follow in Table XXIII.

The effect of zinc as described before, explains the advantageous use of zinc sulfide in some commercial color batches. Recently, zinc thiocyanate was recommended by Loeffler[51].

The foregoing remarks are concerned with the experience of the industry. The results of more recent research, however, should be interpreted as stressing the importance of strictly controlled special heat treatment as well as carefully balanced reduction. It is true that Kirkpatrick and Roberts[49] obtained very good results with pressed and blown glasses high in zinc oxide. Their blown zinc glass did not strike to sealing wax red as easily as the zinc free glass, but their zinc glass was different in base composition, and under adequate thermal conditions the pressed zinc glass was always used in a lens pressing process where, much to the advantage of the coloration, 18 seconds of cooling during "marvering" preceded the shaping proper. Sullivan and Austin[50], in an extremely interesting contribution to the problem of controlled production of selenium ruby glasses, focussed their attention on zinc free glasses, where adequate thermal cycles invariably warranted excellent color. In order to correlate their results to commercial zinc containing rubies one zinc glass was also investigated and the phenomena observed in zinc free glasses were reproduced in principle. The selenium retention was found considerably higher but by no means conducive to an easier development of a good ruby color. The suggestion of these authors with respect to the application of arrested cooling and to a reduction equilibrium sufficient for selenium retention but not too excessive to provoke the loss of cadmium furnish an entirely new aspect. The prevalent assumptions concerning the necessity of using zinc oxide will have to be revised, pending further studies in selenum ruby glasses.

(c) Heat Absorbing Glass

In carbon amber glasses the formation of colorless zinc sulfide is undesirable; zinc oxide, therefore, is not to be used as a constituent of these glasses. In other cases the formation of the smallest amounts of yellowish alkali sulfides may be undesirable and zinc will be the most suitable remedy. On principle, high quality crystal glasses should be free of any hues. Although generally the discoloration caused by iron deserves most of the attention of the glass maker, sulfide colors will interfere with the quality of the ware whenever a chance for reduction coincides with the presence of sulfates. Frequently this is the case. The brilliance of the old zinc crystal mentioned in our introduction is partly due to the absence of any trace of alkali sulfide. If sulfates are a major constituent of the glass and carbon is used to reduce the glass gall the danger is greater. In heat absorbing glasses, where the iron is kept in the infra-red absorbing Fe^{II} (ferrous) form, reducing conditions have to be excessive, sulfates are relatively abundant and zinc was called for as a remedy. In the Corning Glass Works, glasses with, for instance, 50 ZnO (with some tin oxide) to 370 sand were developed to destroy the yellow tint[52 53].

(d) Selenium Pink

In selenium pink, a color produced by elemental selenium, zinc selenite is sometimes used[48] instead of sodium selenite as a source of selenium. Barium selenite and zinc selenite act similarly, apparently due to the fact that they are not as easily attacked by moisture and less liable to decompose at too early a time. In these glasses the influence of zinc on the melting and melted glass is negligible and restricted to the very first part of the melt.

(11) The Effect of Zinc Oxide on Other Glass Colors

The relatively strong influence of zinc oxide on some ionic colors may, again, be correlated with the participation of zinc in the glass structure, or, in other words, with the fact that just as B_2O_3 forms the distinctive class of borosilicate glasses, ZnO may form distinctive zincosilicate or borozincosilicate glasses.

Within the scope of this paper it may suffice to mention the following effects of zinc oxide on colored glass:

(a) ZnO causes bluish hues in glasses containing nickel oxide. Glasses containing barium, potassium, and zinc were observed to show almost red tints similar to that of some strontium glasses colored with nickel. To ordinary soda-lime glasses nickel imparts purple to greyish colors.

(b) In green signal glasses colored by copper oxide the presence of zinc is detrimental to the absorption be-

(*Continued on page* 128)

TABLE XXIII

Selenium Ruby Glasses

Sand	Bohemian[48] orange	Bohemian[48] Grenade	Belgian[48] ruby	Soft Ruby	Working[49] Glass, Exp.	Exp.[50]	American[50]
Sand	100	100	100	SiO_2	53.7		
Soda Ash	18.5	21	28	K_2O	16.25		
Potash‡	12.3	14	10.7	Na_2O	16		
Limestone	10.1	11.5	....	ZnO	1	9.	9.4
Zinc Oxide	12.3	14	18.5	B_2O_3		....	.5
Baryta	....	....	3.	Se		.6	*
Borax	20.5	23	....	CdS	.1	.6	*
Boric Oxide	....	....	2.3	Al_2O_3	....	2.4	.4
Bone Ash	4.	1.1	*	CaO	....	3.2	....
Cryolite	1.	1.	*	MgO	....	2.1	....
Cadmium Sulfide	1.5	2.	*	$Ca_3(PO_4)_2$	....	....	1.4
Selenium	.19	....	*				
Sodium Selenite	....	1.5	*				
Sulfur	.3	....	*				

*Base Glass only

‡Bohemian potash usually contains only 75% K_2CO_3, the rest being Na_2CO_3, KCl, NaCl, K_2SO_4, $NaSO_4$ and phosphates.

CONTROLLED HUMIDITY STEPS UP PRODUCTION OF ARMY GUN SIGHTS

Discovery That Glass Absorbs Moisture Leads to New Plant System by Air Conditioning Engineers

It isn't the heat, it's the humidity!

This discovery has cracked one of the major bottlenecks in the manufacture of precision optical instruments and made possible for the first time mass production of gun sights and other sighting devices for the armed forces.

Millions of Americans who wear spectacles have fumed for years over the fact it is more difficult to clean their glasses on some days than on others, and the same atmospheric conditions that bother be-spectacled citizens have frequently halted precision optical production entirely.

The problem has been solved by engineers of the Minneapolis-Honeywell Regulator Company, working from the surprising fact that glass absorbs moisture. The engineers devised a method of humidity control that has been made available to all other companies producing gun sights and similar material for the Army and Navy.

Anti-aircraft, trench mortar and tank sighting devices require highly polished, microscopically clean lenses and prisms. A speck of dust 1/10,000th of an inch in diameter would look like an approaching bomber if it located itself within the focal plane of an anti-aircraft gun sight.

Steps taken by Minneapolis-Honeywell when this company entered the new field of precision optical production, included conditioning and filtering of air coming into lens cleaning and assembly rooms, insistence that workers wear lint proof clothes provided and specially washed for them and thorough vacuuming of the rooms by powerful cleaners each night. But even these precautions failed to achieve the conditions required by the precision limitations.

The observation of a forewoman—Mary Jane Pell of Wabash, Ind.—who noted that on bright, sunshiny days it was easy to clean glass with rags and small suction hoses but on rainy days the job was almost impossible, focussed attention on the fact that glass is hygroscopic. This means that it absorbs or releases moisture according to atmospheric conditions.

The engineers then proceeded to apply knowledge gained from years of experience in devising temperature and humidity controls for intricate industrial processes and regulating heating and air conditioning.

Study revealed that when humidity is falling, infinitesimal amounts of water come out of glass and distribute minute particles of soluble salts on the surface. This makes the glass rough and sticky. On the other hand, when humidity is rising moisture remains within glass and makes it possible to clean the surface with ease.

When these facts were related the engineers hit upon the plan of controlling the rate of change of the humidity. It was then a simple matter for the company's air conditioning technicians to devise a hand-tailored system to accurately control the rate of humidity change.

When the humidity problem had been solved the Minneapolis-Honeywell company was confronted with still another difficulty—the formation of a thin film or haze which appeared on many of the sights after they were completed and ready for mounting on guns.

Unable to discover the reason for the hazing condition the company took the problem to the Scientific Advisory Committee of the University of Minnesota and asked the assistance of L. H. Ryerson, chairman of the group and professor of chemistry.

Thorough study of the operations involved suggested that oil from the metal casings of the gun sights might be the cause of the trouble. Subsequent investigation proved that tiny oil drops within the interstitial spaces of the metal casings formed themselves on the glass lenses after a certain period of time and were the cause of the haze.

During the early manufacture of the casings oil is used on the machine tools to facilitate cutting operations. The company had been cleaning the casings after machining, but apparently this was not sufficient to thoroughly remove all traces of oil. So, at the suggestion of Ryerson's committee, company engineers tried suspending the semi-finished sights in solvent vapor to evaporate the oil. Following this process the sights were scrubbed with chemicals and water, and baked dry in an oven.

Today all of the sights being made by Minneapolis-Honeywell are scrubbed, washed, suspended in vapor and constantly protected from dust and grease before the lenses are mounted. It is because of the ability of grease to spread that no worker may touch the lenses with his hands because grease from a finger tip, even if it just grazes the edge, spreads out over the lens and fogs vision.

Completed anti-aircraft gun sights built at the plant met all government requirements following introduction of the new vapor-bathing system and the company's technical production problems were about over.

Thus the cooperation of an industrial concern with a university has made possible volume production of vitally needed weapons. The fresh viewpoint of the college, scientists, coupled with the experience of M-H technicians and production men combined to solve a seemingly impossible problem.

ANTI-TRUST DEFENDANTS MAY SHARE EXPENSES

James A. Shanley, receiver for the Hartford-Empire Company in the government's anti-trust action against glass container manufacturers, has asked the court's authorization for his company's share of the expenses to be apportioned among the defendants. This plan was worked out by attorneys for the defendant companies and is being studied by Judge Frank L. Kloeb.

• According to the Libbey-Owens-Ford Glass Company it will take 240,000,000 square feet of glass to provide the necessary windows for the 1,600,000 new homes expected to be built in the first year after the war.

ROGERS BECOMES SALES MANAGER AT LACLEDE-CHRISTY

Mr. John W. Rogers, former assistant sales manager of the Glass Refractories Division of Laclede-Christy Clay Products Company, has been appointed Sales Manager of that division. He succeeds Mr. John H. McKelvey, who died recently.

Mr. Rogers has been in the Glass Refractories Division since 1926 and for several years acted as Mr. McKelvey's assistant. He has had wide experience in glass engineering, manufacturing and construction.

BALL BROTHERS RETURNS TO PRODUCER GAS FOR THE DURATION

The critical stringency of the supply of fuels for industrial furnaces has induced the Ball Brothers Company of Muncie, Indiana, to return to the use of producer gas for the firing of their tanks. Prior to the adoption of natural gas a few years ago, producer gas was used exclusively for this purpose. Some tanks are still operating on natural gas, but it is the intention of the Ball company to convert all furnaces back to producer operation this year. The conversion, however, is intended only for the duration of the war.

COLUMBIA DIVISION NAMES RESEARCH OFFICERS

Dr. Alphonse Pechukas and Dr. Franklin Strain have been appointed Research Director and Assistant Research Director respectively of the Columbia Chemical Division of the Pittsburgh Plate Glass Company.

Dr. Pechukas has been serving as acting director since May, 1942, having entered the chemical division in 1937 as a laboratory research worker. He received his B.S. and Ph.D. degrees from the University of Chicago and is a member of the American Chemical Society and the American Association for the Advancement of Science. Only 28 years old, Dr. Pechukas is among the youngest directors of research in the industrial field.

Dr. Strain received his Ph.D. degree in organic chemistry from the University of Kansas and later became a graduate instructor there. Before going to the Pittsburgh Plate Glass Company, in 1937, he was a research chemist for Luziers', Inc., Kansas City, Missouri, and for Behr-Manning Corporation, Troy, New York. He is a member of the American Chemical Society.

Byron H. Huffman
Vice Pres. and Sales Director

Wiley M. Tye
Sales Supervisor

LIBERTY GLASS APPOINTS NEW EXECUTIVES

The Liberty Glass Company of Salpulpa, celebrating its 25th anniversary this year, inaugurated a new sales program recently by appointing two executives, Byron H. Huffman as vice president and director of sales and Wiley M. Tye as sales supervisor, a newly created position. William W. Alexander succeeds Mr. Tye as district sales representative in Texas.

Mr. Huffman has had twenty years' experience as executive and sales officer for the Diamond Alkali Company, Painesville, Ohio. A veteran of the World War I, Mr. Huffman was awarded the Order of the Purple Heart after being wounded in action. After the war he became credit manager of the West Penn Light and Power Company, Pittsburgh, and joined the Diamond Alkali Company in 1923.

Mr. Tye, formerly with the Three Rivers Glass Company, Three Rivers, Texas, has been with the Liberty Glass Company for ten years as district sales representative in Texas.

Mr. Alexander comes from Ball Brothers, Muncie, Indiana, where he had been the Texas representative for that firm. He had spent twenty years in the utility, manufacturing and oil industries before that time.

• In the absence of Major Edmund F. Ball, who held the position of vice-president and general factory manager of Ball Brothers Company and who is now on active duty with the army, John E. Fisher has been appointed to supervise glass factory operations of Ball Brothers Company.

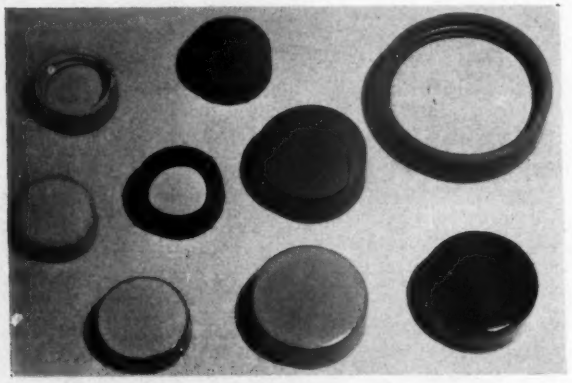
MIRROR COMPANY CONVERTS TO OPTICAL LENSES

The Standard Mirror Company of Buffalo, N. Y., has converted its plant to making highly technical optical lenses for the duration of the war. The amount of war work being done by the plant is "mounting steadily," executives say. Before the war, this company was engaged in producing rear vision mirrors for the automobile industry.

WMC INTERPRETS NON-DEFERRABLE GLASS INDUSTRIES

The War Manpower Commission has interpreted their list of non-deferrable industries effecting the glass industry as follows: cut, beveled and etched glass refers to flat glass which might be used for mirrors, etc.; cutware; glass novelties to be interpreted by the local draft boards; mosaic glass; and stained, leaded, ornamented, and decorated glass refers to cathedral glass, stained glass windows, etc. Local Draft Boards should be advised of the type of glassware being produced in plants in order that they might judge the deferrability of the employee.

The Commission has also stated that it is their intention to try to keep the essential glass industry, as described in Occupational Bulletin No. 34, and other sections of the industry manufacturing necessary items for civilian use, such as tableware, tumblers, cooking ware, kitchen equipment and the like, in continuous operation. They are trying to eliminate all luxury items from the glass industry making every effort to divert such labor into manufacturing war materials.



CERAMIC CLOSURES NOW AVAILABLE IN SEVERAL SIZES

Ceramic closures for glass containers having passed the experimental stage of development are now in actual production and certain products of two nationally known manufacturers, Lentheric and Elizabeth Arden, will soon appear on the market with the new closures according to The Vanderlaan Tile Company, New York, manufacturers of the ceramic caps.

Fired in kilns up to approximately 2000° F the closures being of vitreous composition insure an absorption factor of approximately only one-half of one per cent.

It is further stated by the Vanderlaan company that dies are relatively low in cost and the small quantity of metal required for die making has resulted in a readily available supply of metal for the purpose.

Ceramic closures are not expected to compete with metal or plastic caps since methods of production at the present time preclude the possibility of competitive pricing. However, they do offer a substitute of non-critical material which may help fill the gaps in closure supply. At the present time the caps are being produced in 28 MM, 38 MM and 63 MM sizes, glazed or unglazed.

NEW WPB ORDER TRANSFERS TYPES OF GLASS TO CHEMICALS DIVISION

All chemical material requests from the flat, block glass and laboratory, technical and consumer glassware industry, principally on forms PD-25A and PD-1A and special requests for securing materials used in the manufacture of glass, will be controlled by a new glass unit in the Chemicals Division of the War Production Board. The order for the establishment of the unit was issued on January 29th.

Mr. John R. Hostetter, former Assistant Editor of The Glass Industry, and Mr. Walter Thurn, who was formerly with the Libbey-Owens-Ford Glass Company and Tortensen Glass Company, Chicago, are in the new glass unit.

The formal order is as follows:

Section 1. *Purpose:*

.01 The purpose of this order is to transfer flat and block glass from the Building Materials Division, laboratory and technical glassware from the Safety and Technical Equipment Division and the glassware handled by the Consumer Durable Goods Division to the Chemicals Division.

Section 2. *Transfer:*

.01 The functions relating to the obtaining of raw materials and the production of the above types of glass with corresponding personnel, records and equipment are hereby transferred from the Divisions mentioned in Section 1 .01 to the Chemicals Division.

.02 This transfer does not involve optical or opthalmic glassware handled by the Safety and Technical Equipment Division, fibrous glass handled by the Cork, Asbestos and Fibrous Glass Division and glass containers handled by the Containers Division.

CORNING ELEVATES FIVE EMPLOYEES

Five employees of the Corning Glass Works have been advanced to new assignments according to a recent announcement made by the company. John W. Romig was made Assistant to the Treasurer, responsible for coordination of government regulations; Arthur Agett, Jr., succeeds Mr. Romig as Manager of the Pressware Plant; Walter E. Smith is appointed Assistant Manager of the Pressware Plant, succeeding Mr. Agett; Forest W. Roland will be the Production Superintendent of the Pressware Plant; and Andrew Teachman succeeds Mr. Roland as Shift Superintendent of "A" Factory Production.

Mr. Romig has been with Corning for 14 years, joining the company in 1929 as a member of the Plant Engineering Department. He was Manager of the Pressware plant until his new assignment. Mr. Agett, Jr., has been assistant manager of the Pressware plant since early 1942.

Mr. Smith began his work with Corning in 1928 in the Plant Engineering Department. He formerly helped construct the Parkersburg Plant as Project Engineer.

Mr. Roland was Shift Superintendent of "A" Factory Production before his new appointment, having started with Corning in 1901. Mr. Teachman came to the company in 1918 and has had continuous service in "A" Factory since then.

Research Digest

Practical Interpretations of Glass Technology

The Mechanical Properties of Glass

In the October, 1942, issue of the Journal of Applied Physics, F. W. Preston has presented an excellent review of the various mechanical properties of glass and where possible has shown how these properties compare with those of metals. In fact, Preston states, glass is the best material available for studying the mechanical properties of matter as it avoids many of the complications that materials such as metals, wood, etc., introduce.

Excessive brittleness distinguishes glass from most other materials, the fundamental physical factors involved are the simultaneous presence of a relatively high elasticity, fair to high tensile strength, and a complete absence of plasticity or of ability to store energy or to dissipate it by plastic flow.

From the viewpoint of the physical chemist, glass is an undercooled liquid. This catch phrase has caused much misinterpretation of the viscous properties of glass at ordinary temperatures. Preston shows by calculations that viscosities of the order of 10^{70} poises have no physical meaning in mechanical terms and that the limit is at about 10^{14} or 10^{17} poises.

Theoretically the strength of glass should be in the order of several million pounds per square inch and should stretch to double its length before breaking but actual values obtained by normal testing of rods and laths are only around 10,000 lbs./sq. in. Under normal conditions of load and time it is not safe to figure on a strength of more than 3,000 lbs./sq. in.

In the case of fatigue, new results on both glass and porcelain using longer times than any previously used, show definitely that the curve showing the decrease in strength with time is not a straight line.

New data on the variation of strength with temperature agrees with the earlier results of Smekal and apparently disagree with the recent results of Jones and Turner. Preston's results show that glass when it is really cold, or really hot, is much stronger than at room temperature, the minimum strength being at about 200° C.

Cracks in glass are as distinctive as fingerprints and the study of their point of origin, direction of propagation and other characteristics is known as "Fracture Diagnosis" and has become an important minor branch of physical service. Cracks are propagated in soda-lime glass at a speed of 5040 ft. per second.

Surface abrasions have an extraordinary weakening effect on the glass, particularly against impacts administered from the opposite side of the glass. A crack is an extreme example of a re-entrant angle and when present greatly weakens the glass. Unless special precautions are taken any ordinary piece of glass will acquire surface abrasions and cracks. Ordinary strength tests are therefore made in most cases on glass which is already damaged and the data obtained really show how nearly broken the sample is already. Fortifying the glass surface by HF etching serves to round out the crevices in the abrasions and cracks and causes the strength to increase ten to twenty times.

The absorbed moisture on the glass surfaces also decreases the strength of glass and seems to play a major role in the temperature-fatigue phenomena. This remarkable influence of moisture on the strength of glass warrants additional investigation as the data obtained to date seems to indicate that the absorbed moisture film is one of the causes of the misbehaviour of glass.

Effect of Chemically Formed Surface Films on Glass Solubility

When a silicate glass is treated with acid, acid-soluble oxides are leached out leaving a silica-rich surface film, which is permeable to further acid attack. Jones and Hafner (Journal American Ceramic Society, February, 1943) have reported the results of their study of the effect of baking these films so as to decrease their permeability and render the resulting glass surface more resistant to acid solutions.

It was found that (1) the thickness of a leached film did not need to be great to produce a decrease in solution rate after densification; (2) a thick film gives more efficient protection than a thin film but if the film is too thick it may crack away from the glass; (3) as the temperature of baking is increased the protective action increases unless the baking temperature is so high that the base glass material diffuses into the surface layer; (4) the temperature of baking is influenced by the chemical composition, being higher for glasses containing larger proportions of silica or alumina, and lower for glasses containing more soluble oxides; (5) methods of improving the durability of glass, such as contact with acidic gases, salt vapors, or fused salts before or during the annealing period, probably involve differential removal of some metal ions from the glass surface and subsequent reduction of the permeability of a surface layer.

Amber Glass and the Role of Carbon

This paper by Moore and Scholes (Journal American Ceramic Society, February, 1943) contains much of interest to those manufacturers of amber glass that must meet color specifications. While the primary purpose of the investigation was to show that carbon was not the essential reagent responsible for the amber color the other results obtained have much practical application. For example; iron oxide intensified the amber color to such an extent that the authors believe that no amber would have been produced with the other reagents used if iron had been completely absent. The effect of alkali content experiments confirmed the established opinion that the intensity of the amber color is increased with increasing alkali content. Likewise it was confirmed that reducing conditions are necessary for good ambers, as the amber color could be greatly diminished or prevented entirely by oxidation. If reproducible amber colors are to be made, sulphur is not to be recommended as it may readily boil away before forming sulfides.

CURRENT STATISTICAL POSITION OF GLASS

During January the glass industry maintained a high level of production, employment and payrolls. According to The Glass Industry's Production Index, output during January was estimated at $43,000,000, the same figure as January 1942.

Plate glass production during January totalled 4,910,090 sq. ft. This was 2 per cent under December's total and 46 per cent under the production figure for January, 1942.

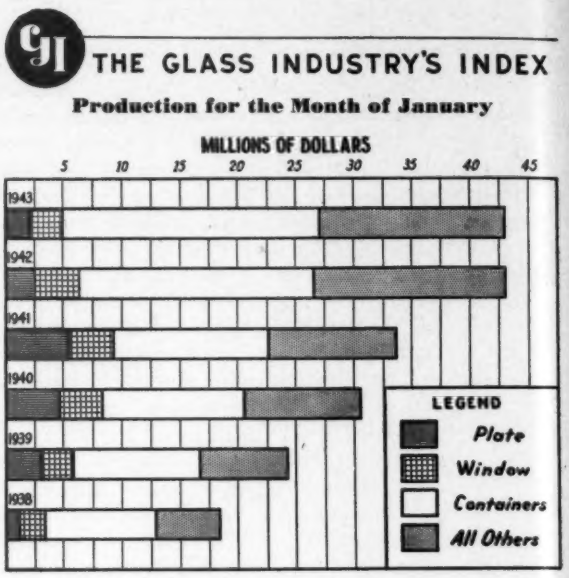
Window glass production for January totalled 1,165,510 boxes representing 71.8 per cent of the industry capacity. This was a decrease of 10 per cent from the previous month's total and a decrease from January, 1942 of 30 per cent.

Glass container production during January amounted to 7,360,661 gross according to the Glass Container Association of America. This was 16 per cent greater than December's figure and a 9 per cent increase over the January, 1942, total.

Shipments of glass containers during January totalled 7,245,708 gross, an increase of 23 per cent over January, 1942, and an increase of 10 per cent over December's total. Outstanding gains reported over last year's comparable month for domestic fruit jars was 274 per cent; for narrow neck food containers, 83 per cent; and wide mouth food containers, 54 per cent. Cumulative figures for the 12 months ending January 31, 1943, reveal that shipments during this period were 13 per cent greater than in the previous comparable months.

Inventories of glass containers showed a 23 per cent decrease at the end of January from last year's corresponding date. Stocks of all types of ware showed a universal decrease from last year's stocks at the same period with the exception of narrow neck food containers and general purpose ware, which showed a slight increase.

Miscellaneous glass products manufactured during January were estimated at $16,000,000.



Automatic tumbler production during January amounted to 4,475,181 dozens, which was 16 per cent over December's figure but 16 per cent under January 1942's corresponding total. Shipments during January showed a slight increase over December's total to 3,762,527 dozens, but a decrease of 9 per cent from January 1942's figure. Finished stocks of tumblers at the close of January totalled 7,876,880 dozens which showed a decrease of 10 per cent from last year's comparable figure.

Manufacturers' sales of machine-made table, kitchen and household glassware during January totalled 3,584,668 dozens or 38 per cent better than last year's figure. During the 12 months ending January 31, 1943, 39,583,030 dozens were sold, a slight increase over the previous 12 months' period.

Employment and Payrolls: Employment in the glass industry during January was estimated at 85,000, a decrease from the 93,000 persons employed in January 1942.

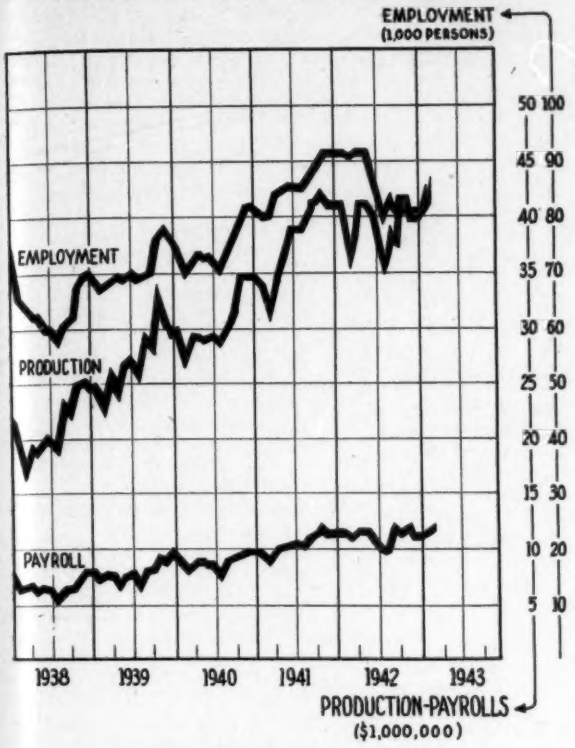
CURRENT GLASS CONTAINER PRODUCTION

(ALL FIGURES ARE GROSS)

	Production		*Shipments*		*End of Month Stocks*	
	Jan. 1943	*Jan. 1942*	*Jan. 1943*	*Jan. 1942*	*Jan. 1943*	*Jan. 1942*
Food Containers	2,454,883	1,584,627	2,372,575	1,519,353	2,079,532	2,430,589
Pressure and Non-Pressure Ware (Narrow Neck, Wide Mouth and Pressed)	449,968	484,603	365,560	351,696	404,096	698,865
Beer Bottles	918,208	572,507	849,431	522,333	347,253	410,458
Liquor Ware	609,412	876,922	796,068	902,281	1,272,628	1,861,939
Medicine and Toilet Ware	1,867,558	2,313,299	1,924,033	1,884,283	2,438,050	3,371,792
General Purpose Ware	617,078	492,297	551,054	400,296	584,813	530,914
Milk Bottles	283,572	273,370	266,765	257,162	334,968	375,578
Fruit and Jelly	138,031	131,151	100,378	28,620	279,626	502,683
All Other	21,951	25,739	19,844	20,458	33,537	45,626
Total Industry	7,360,661	6,754,515	7,245,708	5,886,482	7,774,502	10,228,444

GJ THE GLASS INDUSTRY'S INDEX

Monthly Trends Through January, 1943



Payrolls in the glass industry during January were estimated at $12,000,000, a slight decrease from the previous year's comparable total.

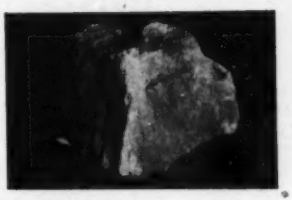
FUEL OIL SHORTAGE HITS CONTAINER PLANTS

Glass container manufacturers who use oil for fuel are facing a serious problem in District No. 1 (eastern area) where their supply has been cut 40 per cent. The indicated attitude of government fuel authorities favors the production of containers for such essential products as foods, drugs and chemicals as an influencing factor in the allocation of fuel oil. Reduction of oil supplies is bound to reduce proportionately the output of containers from the plants which are dependent on oil to fire their melting tanks. In contrast to this dire outlook, it has been predicted by a Washington source that the 40 per cent cut will be lifted April 1, subject to military developments which might change the situation again. No confirmation of this prediction has reached The Glass Industry.

ANCHOR-HOCKING ACQUIRES MAYWOOD GLASS COMPANY

Although details of the purchase by the Anchor-Hocking Glass Corporation, Lancaster, Ohio, of the Maywood Glass Company, Maywood, California, are not available as this issue goes to press, it is understood that control of the Maywood company has been acquired by Anchor-Hocking. The Maywood Glass Company have been manufacturing containers both flint and amber including wide mouth and narrow neck ware.

THIS LITTLE PIECE
OF DOLOMITE LIMESTONE



HELPS MAKE THE GLASS THAT
PROTECTS THE ARMY FOOD

Our army needs glass for food containers, table ware, laboratory equipment, and for windows of ships, planes and buildings.

In civilian life, glass continues to play a very important part. It is replacing many critical materials in which there are shortages. Research men are finding more and more amazing possibilities with glass—glass that will float, glass spun into cloth, glass that bends and glass that will stop a bullet.

Lime and Limestone are as essential in the making of glass as they are in the essential industries of STEEL, BUILDING, AND AGRICULTURE.

THAT'S WHY Banner Lime IS
Essentially yours

NATIONAL MORTAR AND SUPPLY COMPANY
Grant Building, Pittsburgh, Pa.
Since 1907 . . . A good company to do business with

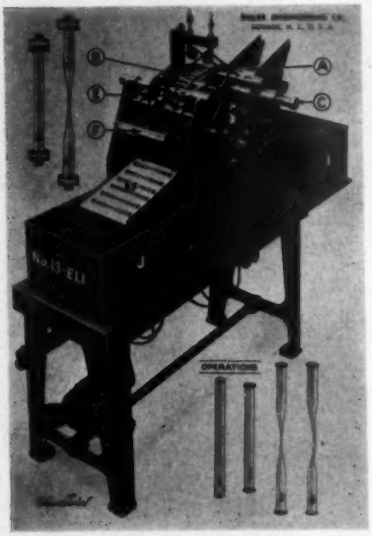
NEW EQUIPMENT AND SUPPLIES

NEW EYE DROPPER MACHINE

Approximately 2,000 eye droppers an hour can be produced on a new motor driven, automatic machine for high rate production which has been developed by the Eisler Engineering Company.

Glass tubing coming from the factory in five foot lengths is cut to a double length or whatever length the Standard Eye Dropper requires. From there the operation is as follows:

A. Feed Hopper: Glass tubing of double dropper length is fed into hopper; operator can fill hopper for approximately 15 to 20 minutes run. Following operations require no further attention.



B. Glass tubes shown lying in grooves of slotted wheel.

E. Two endless chains, rotating counterclockwise, keep the glass tubes revolving at required speed.

C. Two hammers, fixed on one rod, flange the ends of the tubing. Every time the wheel stops, the cam operated hammers make one flange simultaneously on opposite ends of the two tubes, which are adequately heated and annealed by a series of burners.

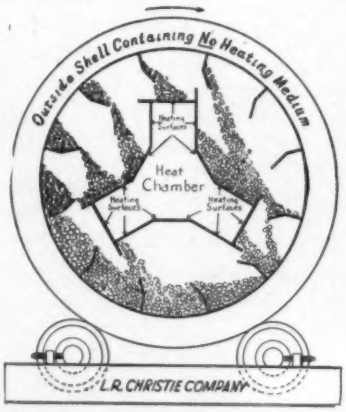
F. Constricting Tool: Consists of two jaws which take hold of both flange-ends and pull apart the sufficiently heated rolling glass tubes to the required double length of the Eye Dropper. G and H show this operation before and after constricting. No. 1 to 4 illustrate the shaping operation. An arrangement is also placed on the machine whereby the constriction can be bent off as shown in No. 4.

After two flanges are completed and the constriction is drawn, the tubes drop out of the machine automatically as shown at 3F. The machine requires one operator and is supplied with ¼ H.P. motor.

DIAMOND ABRASIVE WHEEL

Di-Met Rimlock is the trade name for the new diamond abrasive cut-off wheel manufactured by Felker Manufacturing Company of Torrance, California. This new blade is particularly efficient in cutting all hard, brittle non-metallic materials, such as glass, quartz, porcelain, tile, ceramics, clay products, etc.

The Rimlock differs from former diamond abrasive blades in the special bonding process which rigidly locks the diamond particles in the rim of the wheel without additional crushing during the process and with the benefits of longer life and faster cutting ability. The Rimlock is available in two types: a hard steel bond that makes a stiff and fast cutting blade, and in a copper bond which, though not quite so fast or stiff as the steel, operates with a softer action and with some increase in life. Sizes range in even numbers from 4" to 24" in diameter with a smaller 3" wheel as the one exception.



REVOLVING DRYER SAVES FUEL

The L. R. Christie Company has developed a revolving semi-direct heat dryer which saves on fuel, the casing of the inner chamber being so designed as to provide the maximum heating surface area for the material to be dried.

Instead of placing the material in a central drum or cylinder with the application of the heat through chambers or flues on the outside of this cylinder, the material is placed between the outer shell of the dryer and the inner tube or chamber. The heat or gas passes through a small drum or enclosed chamber which is rigidly suspended inside of and revolves with the large outer cylinder. In this way, no heat is allowed to contact the outer shell.

TESTED SWEEPING COMPOUND

A sweeping compound found to be non-combustible by tests completed recently by the Underwriters' Laboratories, Inc., has been produced by The Philip Carey Manufacturing Company. This new product is called the Grease Ball Asbestos Sweeping compound and is already being used extensively in factories, mills, refineries, power plants, garages and filling stations.

The formal report from the Underwriters' Laboratories stated that this product is "non-combustible, and chemically stable, "that" it shows no tendency to heat spontaneously and will not burn or evolve flammable vapors." It removes deposits of oil and grease from floors, eliminating the hazards of fire as well as reducing the danger from falls. It has no acid or caustic ingredients and will not damage the floor or injure the user or his clothing.

CATALOGS RECEIVED

The North American Manufacturing Company, Cleveland, Ohio. A device for proportioning the flow of fuel oil and air to oil burners called Air Oil Ratiotrol is described in a bulletin put out by the North American Manufacturing Company, and is available on request.

The B. F. Goodrich Company, Akron, Ohio. An engineering work sheet has just been published by the Goodrich Company and added to its catalog on Vibro-Insulators, which is an aid to compiling data for attacking the problem of requiring Vibro-Insulators.

General Electric Company, Schenectady, N. Y. Automatic control by photoelectric relays is the subject of a pamphlet just released by the General Electric Company. It tells how to speed production electronically by use of photoelectricity. This is Bulletin No. GEA-1755-E.

CATALOG & BULLETIN SERVICE

Current catalogs and manufacturers' service bulletins reviewed in this department may be obtained by writing to THE GLASS INDUSTRY.

GLASS HOUSE GREMLINS . . .
(*Continued from page* 106)

Tank Gremlins. Due to the war effort these Tank Fifinellas are very busy knitting sweaters, socks, mittens, etc. All 3-A glass technologists (this may be obsolete by this time) know what happens to a ball of yarn when it drops on the floor so it doesn't require a vivid imagination to see that cords in glass are identical in source.

Seeds and devitrification are indirectly connected with the Tank Gremlin family life. Just as homo sap. (L) keep goldfish in the home so do the Tank Gremlins. If the atmosphere in the fluid medium is not just right the bubbles given off by the Gremlin goldfish can't break through the surface. Seedy glass is the result. The beautiful devitrification crystals that one sees in the microscope also represent a phase of the Gremlin home life. Such artistic objects are merely the flora grown by the Tank Fifinellas in order to beautify the home.

Machine Gremlins are also quite numerous. Drum Gremlins, for example, upset the setting on the I.S. drum causing such defects as thin shoulders, heel taps, poor distribution and the like. Wrong Rack Fifinellas are responsible for incorrect neck rings, plungers and baffle plates. Closely related to the Machine Gremlins are the Mould Shop Widgets who delight in reversing the lettering on the moulds so that 9 comes out 6 and the letter "T" becomes "⊥" on the finished bottle.

Packing-room Gremlins are much too numerous to describe in detail. It may be mentioned that the ones responsible for packing the right bottles in the wrong carton and visie-versie are known as Sleepy-time Fifinellas and that the Go-No Go Gremlin is entirely responsible for the troubles encountered on the customers' filling lines.

It can now be readily seen that the Gremlin problem is quite serious and it should be given some serious thought, for in the language of the Glasshouse Gremlins: "If slattery gleer and a gramsling too along with a pornis whiffle down on a gleaved slayput equals a dashed rang blearum," which freely translated means "Get rid of the alibis and you'll pack 100 per cent."

[1] Those not having a B.A. degree will be pleased to know that Lepus cuniculus are only rabbits.

NEW CMP REGULATION AFFECTS GLASS MANUFACTURING INDUSTRY

While the original Controlled Materials Plan issued by the War Production Board affected primarily those manufacturers of articles made of alloy and carbon steel, copper and aluminum and did not affect the glass industry to any great extent, further amendments and regulations concern the glass manufacturing industry more directly.

The latest regulation, No. 5, issued under the plan deals with repair, maintenance and operating supplies of steel, copper and aluminum. It controls the purchases for these supplies, and establishes procedures for obtaining both controlled and non-controlled materials.

Glass factory managers interested in obtaining a new machine, apply for it on form PD-1A, first ascertaining from the machine manufacturer how much tonnage of any of the above three metals will be required to build it and place this information on the form.

MIX GLASS BATCHES the MODERN SMITH WAY

New Smith 56 cu. ft. Glass Batch Mixer equipped with Dust Boot, installed in one of the nation's largest glass plants.

Dust-Sealed DURING ENTIRE MIXING CYCLE

Promote the HEALTH and EFFICIENCY of your employes by mixing glass batches in a modern Smith Tilting Mixer. It's DUST-SEALED during the entire mixing cycle—no chance for dust or vapor to escape. A sealed charging chute and a sealed rectangular shaped discharge "dust boot" confine both dust and vapor within the mixer drum, thereby effectively eliminating the silicosis hazard. The famous Smith duo-cone drum, with its scientific mixing action, insures uniform batches, improved quality of glass and greater production.

43 Years' Experience

Every Smith Glass Mixer is backed by 43 years' specialized experience in mixer design and manufacture. *Write for catalog.*

The T. L. SMITH CO.
2898 N. 32nd St. • Milwaukee, Wis.

SMITH GLASS BATCH MIXERS

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

Base Materials

		Carlots	Less Carlots
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	50.00	55.00
Precipitated material		55.00	60 00
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00–16.00	18.00
Borax ($Na_2B_4O_7 10H_2O$)			
Granulated	In bulk, ton	42.50	....
Granulated	In bags, ton	46.00	56.00–61.00
Powdered	In bags, ton	51.00	61.00–66.00
Boric acid (H_3BO_3)			
Granulated	In bulk, ton	96.50	
Granulated	In bags, ton	100.00	111.00–116.00
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Cryolite ($Na_3Al\ F_6$) Natural Greenland (Kryolith)	lb.	.09½–.09¾	.10
Synthetic (Artificial)	lb.	No supplies available.	
Feldspar—(published list prices)			
20 mesh	ton	11.00–13.25	
40 mesh	ton	11.50–13.75	
Granular	ton	11.75–14.00	
Semi-granular	ton	11.00–13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags.			
Fluorspar (CaF_2) domestic, ground, 96–98% (max. SiO_2, 2½%)			
Bulk, carloads, f. o. b. mines	ton	34.00	....
In bags	ton	36.40	50.00
Kryolith (see Cryolite)			
Lead Oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.0900	....
In 5 Ton lots	lb.	....	.0950
Less than 5 Tons	lb.	....	.10
Lime—			
Hydrated ($Ca(OH)_2$–MgO) (in paper sacks)	ton	8.50	9.50
Burnt (CaO–MgO) ground, in bulk	ton	7.50	....
Burnt, ground, in paper sacks	ton	9.50	9.50
Burnt, ground, in 191 lb. gross drums	Per drum	1.70	1.80
Kiln Dried ($CaCO_3$–$MgCO_3$) 10x30 mesh	ton	2.00	....
Kiln Dried ($CaCO_3$–$MgCO_3$) 16x120 mesh	ton	2.00	....
Nepheline Syenite, f. o. b. shipping point	In bulk, ton	12.00	15.00
Potassium carbonate—			
Calcined (K_2CO_3) 96–98%	lb.	.065	.0675
Hydrated 80–85%	lb.	.055	.0575
Salt cake, glassmakers (Na_2SO_4) in bags	ton	21.00–22.00	28.00–30.00
in bulk		17.50	
Soda ash (Na_2CO_3) dense, 58%—			
Bulk	Flat Per 100 lb.	.95	....
In barrels	Per 100 lb.	1.35	....
In Paper bags	Per 100 lb.	1.10	
In Burlap bags	Per 100 lb.	1.15	....
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls. 95% and 97%	Per 100 lb.	....	3.00–3.40
Bulk	Per 100 lb.	1.35	2.50–3.00
200 lb. bags		1.4675	....
100 lb. bags		1.5025	....

Special Materials

		Carlots	Less Carlots
Aluminum hydrate ($Al(OH)_3$)	lb.	.031–.034	.045
Aluminum oxide (Al_2O_3)		.07	.09
Antimony oxide (Sb_2O_3)	lb.	.15–.16½	.15½–.17½
Arsenic			
Glassmakers	lb.	.04¼	.04¾
Regular refined white	lb.	.04	.04½
Arsenic trioxide (As_2O_3) (dense white) 99% In barrels		.04–.04¼	.04½–.04¾
Barium nitrate ($Ba(NO_3)_2$)	lb.	....	Open price.
Pyrophyllite (20% Al_2O_3)	ton	10.00	13.00
Sodium fluosilicate (Na_2SiF_6)	lb.	.05	.06–.06½
Tin Oxide (SnO_2) in bbls.	lb.	....	Open price.
Titanium Oxide (ceramic grade)			
In bags	lb.	.14½	....
In barrels	lb.	.14¾	....
Zinc Oxide (ZnO)			
American process, bags	lb.	.07¼	.07½
White Seal, 150 lb. bbls.	lb.	.09¾	.10
Green Seal, bags	lb.	.09	.09¼
Domestic White Seal, bags	lb.	.09½	.09¾
Red Seal, bags	lb.	.08¾	.08¾
Zircon			
Refined Granular (Milled .01–.02c higher)		.03½	.04¼

Coloring Materials

		Carlots	Less Carlots
Barium selenite ($BaSeO_3$)	lb.	....	1.40–1.60
(Commercial, 25% Selenium)	lb.	....	.85
Cadmium sulphide (CdS)	lb.	....	1.10–1.15
Cerium hydrate—			
600 lb. barrels	lb.	....	.65
Chrome Oxide Green, 400 lb. bbls.	lb.	....	.25–.28
Chromite (99% through 200 mesh)	ton	58.25	64.75
Chromite ore (air floated)	ton	58.25	64.75
Cobalt oxide (Co_2O_3)			
In bbls. 350 lbs. or more,	lb.	....	1.84
Less than 350 lbs.,	lb.	....	1.94
Copper oxide—			
Red (Cu_2O)	lb.	....	.20–.22
Black (CuO)	lb.	....	.19–.22½
Black prepared	lb.	....	Open price.
Iron Oxide—			
Red (Fe_2O_3)	lb.	....	.06½–.10
Black (Fe_3O_4)	lb.	....	....
Iron Chromate	lb.	....	.035–.06
Lead Chromate ($PbCrO_4$) in bbls.	lb.	....	.16
Lithium Carbonate	lb.	....	1 25
Manganese, Black Oxide African			
In Paper bags	ton	70.00	78.00
In Burlap bags	ton	71.75	79.75
In Casks	ton	74.00	82.00
Neodymium oxalate, 50 lb. drums	lb.	....	4.00
Nickel oxide (Ni_2O_3), black	lb.	....	.35–.40
Nickel monoxide (NiO), green	lb.	....	.34–.37
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals and Granular	lb.	.09½	.09¾–.10
Powdered	lb.	....	.10¼–.10½
Potassium Chromate (K_2CrO_4) 100 lb. kegs.	lb.	....	.27
Powder blue	lb.	....	.24–.25
Rare earth hydrate—			
100 lb. drums	lb.	....	.35
325 lb. barrels	lb.	....	.30
Selenium (Se) in 100 lb. lots	lb.	....	1.75
In lesser quantities	lb.	....	1.85
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.07¼	.07½–.07¾
Sodium chromate (Na_2CrO_7) Anhydrous	lb.	.08½	.08⅞–.09⅛
Sodium selenite (Na_2SeO_3)	lb.	....	1.50–1.65
Sodium uranate (Na_2UO_4) Orange	lb.	....	1.65
Yellow	lb.	....	1.65
Sulphur (S)—			
Flowers, in bbls.	Per 100 lb.	3.40	3.75–4.15
Flowers, in bags	Per 100 lb.	3.05	3.40–3.80
Flour, heavy, in 250 lb. bags	Per 100 lb.	2.95	3.30–3.70
Uranium oxide (UO_2) (black, 96% U_3O_8)			
100 lb. lots. Black	lb.	....	2.15
Yellow orange	lb.	....	1.65

Polishing Materials

		Carlots	Less Carlots
Pumice Stone,			
American Ground FFF, FF, F	lb.	.04	.04½
0, 0½, ½, 1	lb.	.05	.05½
Putty Powder	lb.	Open price.	
Rotten Stone (Domestic)	lb.	.02¼	.03½
Rouge, Red	lb.	.18	.16
Black	lb.	.15	.18

Boom in war babies!

AMERICA's industrial birth rate is zooming, too. Spurred by war, such wonder children as synthetic rubber, plastics, dehydrated foods, air freighters, have emerged from blueprints and test tubes to reality.

The influence of victory's offspring is far reaching, fast growing. It means new methods and new processes in many different fields. To manufacturers meeting these changes, the technical assistance of the Wyandotte Chemicals Corporation can be of great value.

Wyandotte men are working with more than fifty different industries —expediting the handling of alkalies in textiles, caustic in explosives, chlorine in plastics. They are abreast of developments which . . . once seemingly remote . . . may now have a direct bearing on the "duration" uses and post-war prospects of your own products.

Whether your product is a "war baby" or is long established, the broad experience and research background of Wyandotte experts are freely offered. There is no obligation for their assistance.

• Wyandotte Chemicals Corporation consolidates the resources and facilities of Michigan Alkali Company and The J. B. Ford Company to better serve the nation's war and post-war needs.

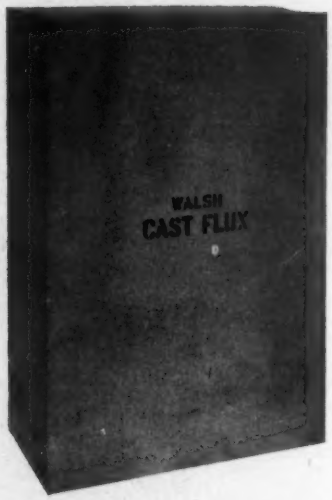
Wyandotte

OFFICES IN PRINCIPAL CITIES

WYANDOTTE CHEMICALS CORPORATION • MICHIGAN ALKALI DIVISION • WYANDOTTE, MICHIGAN

SODA ASH • CAUSTIC SODA • CHLORINE • BICARBONATE OF SODA • CALCIUM CARBONATE • CALCIUM CHLORIDE • DRY ICE

WALSH CAST-FLUX



The Vacuum-cast flux block of superior quality.

Walsh Cast-Flux blocks are machine-trued to exact size and shape after burning.

THEY LAST LONGER

The excellent results obtained in numerous tanks melting various types of glass has definitely established the efficiency and economy of Walsh Cast-Flux blocks.

Walsh Cast-Flux has a dense, uniform structure; it is burned at higher temperatures, is thoroughly bonded and possesses a low coefficient of expansion.

Walsh Cast-Flux blocks meet the most rigid requirements for tanks operating at higher temperatures . . . they insure greater tonnage, higher quality glass, freedom from defects, longer life and maximum economy.

WALSH REFRACTORIES CORPORATION

Manufacturers of Refractories for the glass industry for over 50 years

4428 North First Street

St. Louis Missouri

"E" IS AWARDED TO CORNING AT IMPRESSIVE CEREMONIES

The "E" pennant, coveted award of the Army and Navy for excellence in War Production, is flying today over the Corning Glass Works. The award was made on February 4 amid impressive ceremonies.

The ceremonies began at eleven thirty in the morning when the guests assembled in the Baron Steuben Hotel for a buffet lunch. Officials, directors and executives of Corning Glass Works were all on hand to welcome their guests, which included many important personages in civil and military life. Following the luncheon, the party adjourned to the main factory building for the award and flag raising ceremonies. The Honorable John C. Wheeler, Justice of the Supreme Court of New York State, presided as Master of Ceremonies.

Promptly at two o'clock the Corning Free Academy Band marched into a large manufacturing room of "Factory "A," followed by the platform party. To avoid loss of war production time the presentation ceremonies were held between shifts, and workers and guests joined in a stirring rendition of the national anthem. Col. F. J. Atwood, U. S. A., Chief of the Rochester Ordnance District then presented the "E" pennant. Immediately following the presentation Col. Atwood in reviewing Corning's accomplishments in the war effort, particularly stressed the fact that the "E" for excellence was an award to the men just as much as to the company. While the company flies the pennant, the workers wear the "E" pins. At the conclusion of his address, the pennant was raised on the flagstaff by the Corning Glass Works Color Guard. President Glen W. Cole then spoke in acceptance of the award.

Lt. Commander Paul E. Griffin, U.S.N.R., naval advisor of the Syracuse W.P.B., then presented "E" pins to four representatives of the workers: Mary Hanrahan, Walter Dykins, Robert Gorton, Earl Cortright and Glen Cole. Mr. Cortright accepted them in behalf of the workers, he being chairman of Elected Representatives, Industrial Council. The ceremonies were instituted and concluded with the promptness and dispatch required by a tie-in with a broadcasting hook-up.

Following the "E" pennant ceremonies many of the guests attended a lecture and demonstration of certain Corning products connected with the war effort. As the glass industry well knows, Corning and Research have become synonymous, and this demonstration presented by W. W. Shaver, Director of Product Development Department, which by no means included all that Corning is doing, certainly is an indication of the important contributions its research has made to the war effort. Some of the glass products Dr. Shaver demonstrated may be briefly mentioned:

Kinds of glass: Corning is making some 300 kinds of glass which go into the production of 35,000 items, many of which are used for national defense.

Tubing: Fifty years ago Arthur Houghton developed the method of drawing thermometer tubing vertically. Thanks to this and succeeding developments, Corning is in a position to manufacture tubing for clinical thermometers in quantity for all branches of the service.

(*Continued on page* 130)

ABSENCE OF ARSENIC . . .

(*Continued from page* 107)

arsenic. Self oxidation takes place less readily.

(c) Pentavalent antimony oxide gives off oxygen earlier than arsenic. Less volume is available at the critical time of high fining temperatures.

As a consequence, it appears that more antimony would be required than the equivalent amount replacing arsenic and still this is of little avail if oxidizing conditions can not be maintained long enough. The simultaneous curtailment of niter is a severe limitation of the substitution of arsenic by antimony.

Chlorates and peroxides have been used with some success to create this oxidation without saltpeter.

Are There Other Ways to Fine and Decolorize?

Instead of replacing the couple

Arsenic — Niter

by a couple of similar functions like:

Antimony — Peroxides

a new material could be looked for which decomposes late enough to make a carrier like arsenic unnecessary.

Such a compound exists: it is sodium sulfate. At least .5% sodium sulfate should be used. Much less sodium sulfate is easily reduced to colored sulfides harmful to the appearance of the glass. Much more sodium sulfate leads to a second limitation, the formation of glass gall. Sodium sulfate affects the fluidity of the melt thus calling for some readjustment. Sodium sulfate is to be used without arsenic and antimony.

The oxygen pressure provided by sulfate is inferior to that provided by arsenic.

What About Cerium?

CeO_2 like As_2O_5 can provide oxygen by decomposition into Ce_2O_3 and oxygen. The danger of yellow colorization and the cost make it impractical to use cerium oxide as the sole decolorizing and fining agent. Small amounts (tenths of one per cent) are very helpful to create a beautiful transparency if sodium sulfate is used as the main agent. In no case are even traces of arsenic permissible. The presence of the smallest impurities containing arsenic in batch cullet or dust may cause discoloring. Good looking ware may solarize to yellow brown hues in the daylight. Cerium oxide makes addition of decolorizing colors like selenium unnecessary.

A trace of selenium, or better, neodymium, improves the color considerably.

Summary (See Table)

Arsenic works only in conjunction with an oxygen source like niter. Arsenic can be replaced by antimony with some loss of efficiency and only if oxidizing conditions can be maintained, e. g., by the presence of nitrates, chlorates, peroxides; by sulfates, if enough is used to prevent sulfide formation; more so by also using small amounts of cerium and, incidentally, neodymium. If cerium is used, traces of arsenic must be absent.

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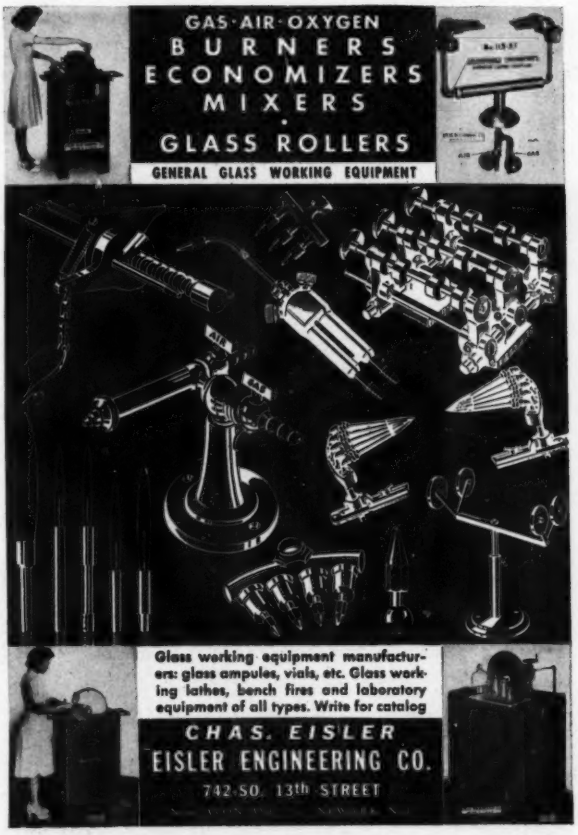
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ZINC OXIDE . . .

(*Continued from page* 115)

havior required by the specifications. The desirable green and blue transmission is decreased in favor of that for longer wave lengths[54].

(c) Similarly to glasses high in silica, silicate glasses containing appreciable amounts of zinc oxide favor the ferrous (Fe^{II}) iron and exhibit the bluish tint characteristic of the presence of Fe^{++}. The analogy with SiO_2 is significant.

(d) The manganese glasses, which are purple due to some trivalent manganese present in equilibrium with Mn^{++} are decolorized by the presence of much zinc oxide. More of the faintly colored divalent manganese forms in zinc glasses. Badger[55] used the combined effect of ZnO on manganese and sulfides (see section (10)) to decolorize glasses with slags as a cheap constituent.

(e) The color of the yellow silver stain and of the red copper stain depend on the base glass; sodium glasses are used for the yellow silver stain, potash glasses for the red copper stain. The influence of zinc on the former cannot be considered essential. L. Springer[56] found certain sodium zincate glasses inferior, but could not find any specific action of ZnO. In the copper stain ZnO is reported to be especially advantageous.[57]

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ENEMY OWNED PATENTS . . .

(*Continued from page* 103)

to the middle of a single sheet of glass. The Engels process brings the wire into the glass at the junction of a V formed by the merging of two flat ribbons of molten glass.

Various laminating compositions are claimed in patents 1,984,671; 2,086,506; 2,124,235 and 2,144,067 all belonging formerly to the I.G.F. Aktiengesellschaft, Frankfort-on-the-Main, Germany. In the first of these, glass sheets are united with a condensation product of maleic anhydride and 1.3 butylene glycol. A product "of the conjoint polymerization of vinyl acetate and acrylic acid ester" is used in the second, and "an isobutylene polymer having a molecular weight of at least about 1000" in the third patent. The fourth patent describes the binding of laminae in the same way with a "conjoint polymerization (product) of vinyl chloride and vinyl butyrate."

The February, 1942 Glass Industry dealt with and illustrated on pages 62-63 the process and apparatus of patent 2,268,489, granted to Adolf Kampfer of Berlin for uniting sheets of laminated glass at an acute angle so as to avoid air entrapment. This patent has been vested as his patent 2,038,494 for a method of joining glass laminae by a partially polymerized resin which is hardened to more complete polymerization at the edges by the action of pure oxygen.

Patent 2,087,090 issued to Otto Hauffe of Eilenburg, Germany (Deutsche Celluloid-Fabrik) concerns the bonding of safety glass with mixed polymerization products of vinylchloride and an acrylic acid ester, applied as a fine powder and then bonded by heat and pressure.

Still other bonding compositions and processes for safety glass comprise the W. O. Herrmann patents assigned to Chemische Forschungsgesellschaft, m.b.H., Munich. These are 2,033,377 in which an excessively thick layer of plastic between glass is squeezed to the desired thinness and allowed to harden free from pressure which would set up strains, 2,135,075 wherein the intermediate film comprises a polyvinyl alcohol and suchrose, and 2,143,482 in which non-fogging sheet is produced by adhesively uniting to one of the outer surfaces a film which contains polyvinyl alcohol.

In the manufacture of window glass by the horizontal drawing process of patent 1,741,912, issued to Max Bicheroux of Aachen, Germany, the glass is rolled into a primary sheet of considerable thickness and is then stretched outwardly to reduce thickness by so-called grippers.

A device and process for tempering sheets is the subject of patent 2,137,061 issued to Alberto Quentin of Florence, Italy. The cooling jets follow predetermined paths which are overlapping ovals. Another tempering patent is 2,237,982 granted to Edoardo Ferlito of Milan, in which tong marks are avoided by supporting sheets at marginal strips which are later broken away.

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CORNING "E" . . .

(*Continued from page* 126)

Signal lights: These are used extensively for airport, harbor and ship lighting. Mechanical strength, resistance to weathering and the permanence of standardized colors are essential properties. An interesting type of signal light is the portable marker (brown, yellow, red) which advance parties carry with them when taking over an airport. With airport lights must be included signal beacons.

Light Transmission glasses: Glasses which permit the passage of ultra violet or infra red rays, but which block out other hands in the spectrum, have important military uses.

Vycor Brand Glass: The remarkable thermal stability of this new glass and its hardness has made it useful in defense work. One of several demonstrations was tape woven from fibre glass made of this new glass. This did not burn or melt when subjected to a blow torch. Incidentally, fibre glass itself has been found to have so many military uses that 95 per cent of the output is controlled by priorities.

Optical glass: Instituted at Corning in 1938 as a peacetime project, optical glass has become a primary contribution to defense production. Dr. Shaver stated that there is ample production of optical glass in the country at the present time.

Electric Welding of glass: An apparatus has been developed for welding glass to glass. It has innumerable applications which are just beginning to be discovered.

Glass Eyes: Production of these glasses was formerly restricted to Europe.

Glass Bearings: They are used extensively in instruments, as in bearings for watches, replacing sapphires in all but the more costly mechanisms. They have many uses in airplanes.

At the conclusion of this demonstration, Mr. Amory Houghton presented Col. Atwood and Commander Griffin with pieces of optical glass taken from the first melting made at the new Corning plant in Parkersburg, W.Va.

NITRE DEMAND REACHES CRISIS

Unless manufacturers of table, illuminating, and miscellaneous glassware reduce their demand for nitre, the government will be forced to curtail its use in glassware except for the manufacture of essential items, such as scientific, optical, and laboratory ware, according to reliable information reaching THE GLASS INDUSTRY. The industry has purchased almost the entire estimated requirement of nitre for the year of July 1, 1942 through June 30, 1943.

Since January 1, 1943 nitre has been forbidden to the container industry, but the WPB has been unusually liberal with manufacturers. However, further curtailment will be necessary if the present rate of consumption continues.

• To assist manufacturers in organizing the record keeping and accounting required under the Controlled Materials Plan, Harold Boeschenstein, Director of the CMP Division, announced that a Consumers Allotment Accounting Manual will be available at the end of February. The manual will merely suggest simple methods that may be used in working out required records.

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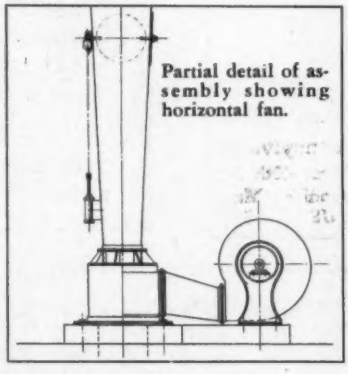
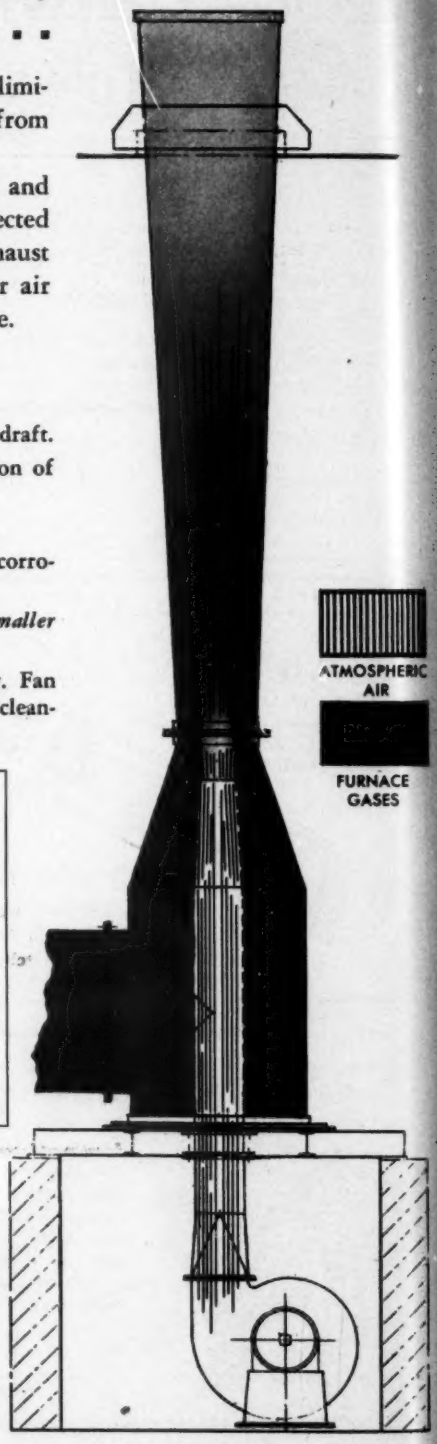


Partial detail of assembly showing horizontal fan.



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